A

T H E S I S

ON

THE SCOPE AND LIMITATIONS OF DYNAMIC GAMES IN MANAGEMENT EDUCATION

BY

HOWARD ANTHONY GREENWALD

SUBMITTED TO

THE VICTORIA UNIVERSITY OF MANCHESTER

FOR

THE DEGREE OF DOCTOR OF PHILISOPHY

OCTOBER, 1966.

ProQuest Number: 11009838

All rights reserved

INFORMATION TO ALL USERS
The quality of this reproduction is dependent upon the quality of the copy submitted.

In the unlikely event that the author did not send a complete manuscript
and there are missing pages, these will be noted. Also, if material had to be removed,
a note will indicate the deletion.

ProQuest 11009838

Published by ProQuest LLC (2018). Copyright of the Dissertation is held by the Author.

All rights reserved.
This work is protected against unauthorized copying under Title 17, United States Code
Microform Edition © ProQuest LLC.

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 – 1346

G. 18188

Thesis
375.33893
G 104
Q

The University of
Manchester Institute of
Science & Technology
16 FEB 1970
LIBRARY

MANCHESTER
UNIVERSITY
LIBRARY

Dedicated to the memory of

Mary Levinsky Greenwald

Mother, Wife, Teacher, Humanitarian

- a complete success in her life.

"ANDIAM! INCOMINCIATE!"

The final sentence in the Prologue
of Leoncavallo's "Pagliacci."

A B S T R A C T

The writer discusses the history and development of management games and the types of management games which are available. He discusses the objectives which trainers have in using games and some of the problems which they have encountered. In discussing the solution to one of these problems he develops the use of sociometric scales.

Another problem discussed is the method of game scoring. As a solution for this the writer developed a special purpose analogue computer and the use of this machine is shown. Examples of games scored by hand, digital computer and the analogue computer are given.

The author discusses attempts at validation of this teaching technique by other writers and then shows his own approach to validation based on impressionistic attitude survey.

After discussing in detail the groups tested and the games and tests used, he demonstrates the validity

of both the games as a teaching device and the test as a measuring tool. Correlation, factor analysis and analysis of variance are all used in these validity tests. He shows the result of high anxiety on learning and the change in response when it is overcome.

In his final chapter he discusses his ideas for the extension of the technique of gaming to its use for developing a Controlled Learning Environment within which management teaching would take place. He also discusses possible extensions of the use of the test scales to study other areas of learning.

A C K N O W L E D G E M E N T S

The author wishes to express his sincere gratitude to Professor R.W. Revans and Dr. A. Roberts.

To Professor Revans for his help and supervision during the initial stages the first four years of the research, and most particularly for his guidance in the statistical evaluation of the data.

To Dr. Roberts for his help and supervision in the preparation of this thesis for presentation, and most particularly for the friendship he has always shown whenever his help was needed.

The co-operation of Mr. S. Subramanian in providing and organising the computer programme for factor analysis is greatly appreciated.

Special thanks also go to my wife Judith Ann for her constant help and encouragement during this research.

To the hundreds of managers who participated in the simulations and then spent the time to conscientiously respond to the questionnaire, my grateful thanks. I hope that the learning which they apparently did was repayment in full.

My thanks to the many people who have helped in organising the courses in each of the firms and associations who participated.

My thanks to Dr. Michael G. Hartley for his help in designing ATHENA. To Electronics Associates Limited for building the first working model which was used in this research.

Lastly my thanks go to the Professors and Staff of the Department of Management Sciences who have always provided an atmosphere which encouraged and stimulated research.

T H E A U T H O R

In 1958 the author graduated from the Wharton School of Finance and Commerce of the University of Pennsylvania with the Degree of Bachelor of Science in Economics, having specialised in Industrial Relations and Psychology.

He attended the Stevens Institute of Technology in the academic year 1958/1959. On presentation of his thesis on "Replacement Analysis" he received the Degree of Master of Science in Industrial Management. In the academic year 1959/1960 he lectured on Statistics in the Department of Finance at Louisianna State University.

He took up an appointment as Visiting Lecturer in Management in the Management Science Department of the Manchester Institute of Science and Technology in 1960. In 1962 he joined a major American computer manufacturer as Deputy General Manager in England and Assistant to their International Vice-President. He retained his lectureship on an honorary basis and continued his research. In 1963 he rejoined the Department as a permanent member of Staff, and has held that position for three years.

C O N T E N T S

L I S T O F T A B L E S

A N D I L L U S T R A T I O N S

CHAPTER 1

INTRODUCTION

In spite of the widespread interest now being shown in management education throughout the world, there is still a great disagreement about how best to educate young men for business and businessmen for advancement in industry. In the introduction to "Higher Education for Business", Gordon & Howell[1] state:

> It is probably safe to say that in no other area of professional education (unless it be education for teaching) is there so much uncertainty as to what constitutes a proper educational background for professional practice, or are existing educational standards and practices viewed with greater scepticism."

In 1957 against this background of uncertainty, the idea of training managers by simulation was

---

1. R. Gordon & J. Howell. "Higher Education for Business". Columbia University. New York, 1959.

finally brought to reality. I set out to examine ways by which these simulations were being and could be used for training managers, to try to find a better way to use them, and finally to test the validity of my new approach to teaching management.

When I came to Manchester University in June 1960 and decided to pursue the subject of Management Games for research, I was faced with the problem of little or no publicly published information available. When I started my field work in November 1960, I could find only four printed articles on the subject, as most games had been adapted by private companies or universities and were being used internally. By January of 1961 I had acquired three American Games which I Anglicised and introduced to students at the College and to managers in one or two local firms. In May I developed contact with the English Electric Company and started to examine the possibilities of writing a medium scale digital computer exercise in the area of production management. Oldham & Sons of Denton co-operated at this stage by giving detailed information about the operation of a Battery Factory which I had decided to simulate in this exercise.

During the summer of 1961 I went to the United States and attended two seminars which extended my contacts and gave me the mathematical techniques necessary to build computer simulations. The first was run at the American Management Association at Saranac Lake, New York and took place in mid July. The second was run by the Carnegie Institute of Technology in Pittsburg and ran through the summer. At this conference they showed the techniques used in the text. On returning to the U.K. in September 1961 I adapted and changed a simulation model of an American game and this was re-programmed by the staff of English Electric at Kidsgrove, Staffs. and became, after some six months of reliability tests, the English Electric Production Management Game, Mark 2. Early in 1962 this game was used as the basis of a five week management development programme which I ran for 24 middle managers at Kidsgrove. It was with this group that checks on the validity of the exercises were started.

In February, 1962 a programme of games, developed

by Clive Lovelock of the Leeds College of Commerce and myself, on a very different level of sophistication was started at U.S. Industries, Burtonwood. These games were of simple design concentrating on only one management function, e.g. Storekeeping, Production Control and Financial Control. In September, 1962 a similar series of exercises was started in two divisions of Lloyds Packing Warehouses Limited.

Both companies faced similar problems in so far as they had been newly acquired by a large gruup and a completely new management structure was being developed and trained. Both of these companies participated in the development of the validation tests used for this thesis.

During this period I was also working on the Mutech simulation which is a very complex digital computer simulation of a machine shop. The machine shop simulated is part of Oldham & Sons. It was found after completion of this simulation that a useful run of it would take about one month full time, and therefore its practical usefulness was negligible. A precis

of the model is included in the Appendix.

By this time I had developed a large library of both hand operated and digital computer operated games. I had used these games on groups varying from 6th form economics students to a group of managing directors of large European companies, brought together for that purpose by Management Centre Europe in Brussels in October, 1962.

I felt that by the beginning of 1963 I had begun to find a number of serious problems implicit in either hand scoring or digital computer scoring in games. These problems are discussed at length in Chapter 5. I tried to find a number of solutions to these problems. One solution which I introduced at a conference which I ran with Clive Lovelock for the European Association of Management Training Centre in Lausanne (April 1963) was to use Normographs, as the basis for computing results in hand operated games. This is shown in Chapter 6.

The second solution which I tried was to use a small punched card processing machine (ICT 1004) which

was launched in 1962, instead of a digital computer. I felt that with the large number of these machines which would be installed that finally a common computer would be available to all educationalists. For this machine I wrote a simulation called ASSET (Analytical Simulation for Sequential Executive Training) which was a general management simulator. Unfortunately in practice, although a large number of these machines were installed, none were in universities or in companies which were large enough to consider an executive development programme. These machines are in fact used for general accountancy in small to medium sized firms. These problems led me to consider the building of an analogue computer which would avoid the pitfalls of the other two methods.

The main cost and size problem with analogue computers was the desire for extreme accuracy - 1/1,000 of 1%. In management I would feel that a decision $\pm$ 5% would be extremely accurate. Therefore I found that by eliminating the most costly analogue component - the amplifiers - we could develop a machine which was cheap, practical and portable. After designing the

basic structure and capacities of the machine I turned it over to Dr. Michael Hartley in the Electrical Engineering Department of the Manchester Institute of Science and Technology, who designed the component that would make it work reliably. A provisional patent was taken out in both our names. (The patent specification is included in the Appendix). Electronics Associated Limited then turned the designs into a practical reality, see Chapter 5.

In January 1964 I presented a paper on the Analogue Computer at the International University Contact seminar on "Didactics of Management Games". During the beginning of 1964 I finalised the form of the test questionnaire to be used in studying the validity of my simulations and secured the co-operation of two industrial federations, (British Federation of Master Printers and Engineers Employers West of England Association) towards providing the subjects needed for the final validity tests. Special games were written using the analogue computer for these groups and the programme of training began towards the end of 1964. After 17 months had elapsed the questionnaires were circulated and I began

my statistical analysis to show the validity of these games, and test the validity of my test.

C H A P T E R 2

WHAT ARE MANAGEMENT GAMES

DEFINITION

A management simulation or game may be defined as a decision-making exercise which is sequential in nature. It is built around the model of a real or imagined business situation. The participants assume the roles of the managements of the simulated business and operate in competition. The use of the word "game" to describe this activity is both appropriate and unfortunate; unfortunate in the sense that it does not suggest the serious educational tool that it is; appropriate because these simulations are competitive and enjoyable and sequential, as most games are. Perhaps the most appropriate form of definition of simulation is an actual description of the operations involved in using one for educational purposes.

a) A written description of the simulated industrial situation is given to the participants. This will generally contain details and history of the simulated

industry and the competition therein. It also contains the accounting and decision forms and the description of their use.

b) Next a briefing session is held during which an oral description of the materials is given by the "umpire" of the use of the decision and operating statements, as well as a further review of the background of the industry.

c) The participants are divided into teams, and each team is then asked to organise itself. This may be a formal organisation which is written down as an organogram or, less preferably, an informal organisation. The team then analyses the data available and writes an operation policy which will form its basic guide lines.

d) The team then makes its first operating decision. This decision may represent a week, month, quarter, or even a year, of operating.

e) The "umpire" then calculates the operating results for each team relative to the model and the actions of their competitors. This calculation can be done either manually or with the use of a digital or analogue

computer. The results are then fed back to the participants with any additional environmental information that may be felt to be ~~relative~~ relevant.

f) This cycle of decision-making feed-back and analysis goes on until the "umpire" feels that an evaluation of results and learning is called for. The cycle is then broken and the "debriefing" session is held. During this, results, and more importantly, the reasons for results are discussed, openly and frankly. If the "umpire" feels there is any further educational benefit to be gained, the cycle of decision and feed-back is started again; if not, the exercise is complete.

HISTORICAL DEVELOPMENT

In attempting to find the historical origin of management simulation, one finds two basic branches which seem to lead to their development. These are - (a) war games, and (b) past methods of management training.

The very earliest types of board games, such as the oriental game of Go, or the game of Chess, although

today used for entertainment, were developed based on war-like strategies with war-like pieces.

WAR GAMES

By 1811 Von Reisswitz had already developed the idea of Kreigsspiel for use in training military personnel in tactics. These games were widely used in Germany during the 19th century and by all modern armies in the 20th century. In 1872 Captain Baring of the Royal Artillery introduced war games in the British Army.[2]

As part of their preparations for World War II the Japanese engaged in some extremely ambitious war games at the Total War Research Institute of Japan.

> "Here military services and the government joined in gaming Japan's future actions: internal and external, military and diplomatic. In August, 1941 a game was written up in which the two year period from mid-August, 1941 through the middle of 1943 was gamed, was "lived through" in advance and,

2. Clayton J. Thomas "The Genesis and Practice of Operational Gaming". The proceedings of the first international conference on operational research published by the Operational Research Society of America. Baltimore 1957. P.65.

of course, at an accelerated pace. Players represented the Italo-German Axis, Russia, United States, England, Thailand, Netherlands, East Indies, China, Korea, Manchuria, and French Indochina. Japan was played, not as a single force, but as an uneasy coalition of Army, Navy, and Cabinet, with the military and the Government disagreeing constantly - on the decisions to go to war, on X-day, on civilian demands versus those of heavy industry, and so on. Disagreements arose and were settled - in the course of an afternoon, at a pace of this game -, with the military group, by the way, as the more aggressive one, winning arguments.. Measures to be taken within Japan were gamed in detail and included economic, educational, financial and psychological factors. The game even includdd plans for the control of consumer goods plans, incidentally, which were identical with those actually put into effect on December 8th, 1941".[3]

---

3. Robert D. Specht. "War Games". P.1041. The RAND Corporation, 1957.

Their method of operation is fairly similar to the business simulations which have been derived from them, but of course, the outcomes are vastly different.

There are two main types of war games ....

a) Free Kriegsspiel - here the basic short outline of some of the fundamental rules of warfare was drawn up, e.g. a division of mounted cavalry will over-run a division of entrenched foot soldiers, and these rules were then applied to a specific military game situation by experienced military personnel evaluating the activities of younger personnel participating in the game.

b) Rigid Kriegsspiel - in this form all the possible rules affecting any military situation were written down in large books. These books then formed the basis for all action that could be taken by the participants. Every possible occurrence was supposedly covered by these rules. If a participant took an action outside these rules it was disallowed. Clearly an idea such as Blitzkrieg, which was developed with the use of Free Kriegsspiel would have been impossible

with the more rigid form.

In his "Introduction to War Games" M.G. Weiner says,

> "At the present time the two major forms of war games, the free play and the rigid play, still exist. Both have been employed as techniques for analysing and evaluating military tactics, equipment, procedures, etc. The free play game has received support because of its versatility in dealing with complex problems of tactics and strategy and because of the ease with which it can be adapted to various training, planning and evaluation ends. The rigid play game has received support because of the consistency and detail of its rule structure and its computational rigor."[4]

MANAGEMENT TEACHING

If one looks at the development of ideas in management teaching, it is clear to see that these ideas were in general heading towards the techniques of simulation.

---

4. M.G. Weiner. "An Introduction to War Games". P.1773. The RAND Corporation, 1959.

Originally, when management teaching started at the Wharton School of the University of Pennsylvania some 90 years ago, the only manner of teaching was by lecture.

Before the Second World War the idea of using "photographs" of the past which could be discussed was developed at the Harvard Business School. This idea was called case study and its use has spread quickly throughout the world. After the war a number of newer ideas were brought forward, such as the incident process which is a derivation of case study and role playing. In-Basket techniques, that is the use of a simulated correspondence and message file for giving participants, insight into management action, have been used to increase the involvement and participation by the students. While they can in many cases be used to simulate a particular point in time or a particular action situation, they do not and cannot have the sequential learning situations created by a simulation.

The ideas developed by the operational researches have also been invaluable as foundations in the sense that these are the techniques which are used in the original model building for simulation.

The earliest attempt at a serious teaching exercise which had a time dimension that I could find was "The Money Game" by Norman Angell.[5] In this game the participants were forced to create a new monetary system. In the foreward Professor Ernest Patterson of the University of Pennsylvania says:

> "I feel quite sure that this game is an excellent medium through which a better appreciation of these principles can be secured - a better medium than much of the formal teaching that we do, especially with younger students."

However, the important element of a pre-programmed relationship was not included.

In 1956, bringing together the war game programming experience of such people as Franc Ricciardi and Clifford Kraft and the management training experience of the American Management Association, the first management simulation called Top Management Decision Simulation was written.[6]

---

5. N.N. Angell. "The Money Game - A New Instrument of Economic Education". J.M. Dent. London, 1928.
6. F.M. Ricciardi, C.J. Kraft, etc. "Top Management Decision Simulation". The AMA Approach. American Management Assoc. Inc. New York, 1957.

By September, 1957 this game was included in the training course held at the American Management Association Academy at Saranac Lake, New York, using the I.B.M. 650 Computer installed there for that purpose. In December, 1957 Lawrence A. Appley, president of the A.M.A. discussed the new technique in "Executive Decision Making: a New Strategy" in the american journal, "Think".

By March, 1958 the Harvard Business Review published the article, "Business Games - Play I", by G.R. Andlinger. This game written by Mr. Andlinger and Mr. J.R. Greene was the first of the non-computer games which was scored by clerks using desk calculators. Within 2 years Greene had already published a whole book full of hand operated management simulations[7], and both I.B.M. and Univac had already developed and published a series of executive simulations based on computer use. In 1960 Arthun Weiner's new textbook, "Introduction to Business: A Management Approach", published by Irwin included a game by E.W. Martin as a separate pamphlet. The

---

7. J.R. Greene and R.L. Sisson. "Dynamic Management Decision Games". John Wiley, New York, 1959.

stated idea was to use the game to integrate the text material. The universities were not far behind with U.C.L.A. and the Carnegie Institute of Technology in the forefront. Today, literally thousands of businesses use games as a significant part of their executive development programmes and hundreds of universities have games which they have written for use in both training and research.

Some of the games are extremely complex, such as the Carnegie Game, which simulates the detergent industry in the Pittsburgh area. It is played during the Second Year of the M.B.A. programme and occupies at least 50% of the total time spent during that year. Other games are very simple, such as the Case Institute of Technology Word Game, where a simple situation, similar to Scrabble, is exploited with different communication patterns to demonstrate their effectiveness, and to stimulate students to discuss the problems involved in differing communication patterns.

CONCEPTS OF LEARNING

As I was interested in games as a teaching device, I

also became familiar with the writings of several educational psychologists on the subject of learning. C.M. Fleming states:

> "a) 'learning takes place not as a consequence of mere subjection to impressions nor from mere repetition of experiences .... it requires activity on the part of the learner'; b) 'changes in behaviour result from changes in the total situation in which an individual finds himself or from alterations in its meaning to him'; c) 'learning .... seems to take place by a series of successive clarifications of concepts, increments in skill, or modifications in attitude'.[8]

After this reading I developed ten concepts of learning which correlate with the views of some of the leading academics. I find that they strongly suggest that simulation should be a useful technique:

1) Learning is re-enforced by REPETITION.

---

8. C.M.Fleming. "The Social Psychology of Education". Routledge, 1944.

2) Learning is more effective if more faculties are brought into the learning process (sight, hearing, writing, THINKING).

3) Learning is enhanced if the dissatisfaction with the status quo comes from within (DESIRE in the trainees).

4) Learning is more effective where the student plays an ACTIVE part in the learning process.

5) Learning is more effective in a SMALL GROUP working towards specified objectives.

6) Learning is enhanced by personal INVOLVEMENT.

7) Learning is more effective if the situation has (at least) the appearance of REALITY.

8) Learning is re-enforced by a prompt FEED-BACK of the results of previous exercises.

9) Learning is enhanced by a CONTINGENCY between present and past learning.

10) Learning is enhanced if further material brought into the learning situation is in the SAME problem areas.

C H A P T E R 3

OBJECTIVES IN USING GAMES

ADVANTAGES.

We have, in the past, used many different forms for off-the-job training to develop management skills. We started with the formal lecture as used in other faculties of university teaching and worked our way through the areas of case study, role playing and the incident process. Each of these has given the training executive some new advantages over previous techniques.

What new features have management games which make them such an important management tool? (1) They offer objective feed-back based on programmed relationships - this means that the executive in the training environment must live with every decision which he makes as the outcome of his past decision will be the starting conditions for his next decisions. Each decision will be marked in the same model; therefore emphasis is laid on the players studying the reality in which decisions are to be taken. The more he can learn about this reality, the better his decisions will be. (2) They add the time dimension to training situations - if we wish to

train a doctor, we give him a cadaver which he dissects and from it learns about the human anatomy. If we wish to train a surgeon, however, we must have him operate in training on live animals. The reason for this is that if a heart operation takes three hours, it might be quite a successful operation, but the patient dies. In business also executives operate in one particular time dimension, and the decision must be judged against the environment at the time it was taken.

The decision simulation is a simple abstraction of a much more complex reality. While many important properties of the reality are preserved in the abstraction, there are several significant differences, Time is compressed. Teams may have only twenty minutes to analyse past results and make decisions for future periods. The market itself is greatly simplified and responds to decisions on the basis of a set of relationships that are usually derived from general assumptions of market behaviour, rather than the specific structure of some particular market. Moreover, many important opportunities that exist in actual operations are not

present in the exercise. For example, there is generally no opportunity to develop a new, more efficient production technology, to bring out an entire new product, or to move into an entirely new market. I believe that participants should be cautioned to disregard almost entirely most specific relationships that may be encountered in most games, since they may have no validity at all in a particular real situation. What, then, is to be gained by participation in a simulation exercise?

OBJECTIVES

Perhaps the best way to describe what I think is the real value of an exercise is to borrow certain basic concepts from the theatre. There are many interesting parallels between the simulation exercise and a serious play. Each tries to provide entertainment, but is also intended to be more than simply entertaining. Each involves abstraction, exaggeration and, generally, significant time compression.

In a play, the author and the actors are not trying to extend the experience of the audience by presenting

useful facts about the world. Indeed, many of the most forceful and effective dramas involve events and surroundings that are totally unrelated to the day-to-day reality of the audience. A good play alters, not our experience, but the manner in which we interpret our experience. Old facts take on new meanings and future experience is seen with improved understanding. An effective play provokes insight.

This is precisely the purpose of a simulation exercise. In effect, the exercise is a play in which the participants are simultaneously the audience, the actors, and, to a large extent, the playwright. The exercise attempts to dramatise certain critical aspects of business planning and management in order to provoke new insight, new understanding of these problems. The hope is that a simulation will help the participant view future business problems as an integrated whole rather than attempting to solve them piecemeal.

In 1958 Albert Schrieber stated:

"The objectives of the business game are:

1. To give experience in decision making in a dynamic, competitive business environment

requiring the integration of many business forces from the top-management point of view through the use of rational skills.

2. To help in developing a way of thinking about decision-making rather than specific strategies which may be successful in one situation but will fail in another.

3. To give practice in the human relations aspect of reconciling different points of view between members of a team in order to obtain a positive course of action.

4. To give the specialist an opportunity to see the analytical relationships of his area to the other functional areas in the business. The specialist must broaden his point of view and learn sympathy, respect, and understanding for the decision-makers outside his own narrow field. This in turn helps the specialist to be more effective in his function as well as more useful to the business as a whole.[9]"

---

9. A.N. Schrieber. "Gaming - A New Way to Teach Business Decision Making." University of Washington Business Review. April, 1958.

Below are several of the specific teaching objectives which the present writer has found achieved in various simulations programmes which he has run:

Increasing the participants perception that the achievement of organisational goals must be managed.

Increase the amount of quantification in decision making.

Develop the use of strategy.

They tend to broaden the functional outlook of participants and force them to examine management problems from the enterprise point of view rather than the departmental point of view.

They show the dynamic balance between interacting managerial functions. A decision cannot be taken in one department without having repercussions in other departments.

Develop stressed intergroup relations which will create learning situations in communications and human relations.

Show the power of the modelling concept.

Acquaint participants with the action of business of all phases of the business cycle.

Dramatically illustrate the effects of incompleteness of information.

Allow experimentation.

Give meaning to "risk taking" to members of management not able to do so in real life.

This list covers the spectrum of achievements which empirical observation and interviews have indicated to me. It must also be stated that they are never achieved simultaneously nor in all cases is any learning shown.

PROBLEMS.

There are problems as well:

Plattner and Herron mention:

> "1. There is sometimes so much enthusiasm about the involvement of participants and the intricacies of mathematical models and computer programmes that insufficient thought is given to the determination of an adherence to sound educational objectives.
>
> 2. Participants tend to forget that what worked well for them in the operation of a certain simulation model may not work well in "real life", where the structure of relationships may be different from and more complex.
>
> 3. Because participation in a simulation is usually enjoyable, there is often a tendency

> to devote too much time to the play and not enough to carefully analysing and critiquing the results achieved.
>
> 4. Simulations to date have placed a primary emphasis on the quantitative aspects of management."[10]

Many of these problems can be overcome by the umpire in his direction during the briefing and debriefing sessions.

In his paper "Educational Effects of Management Games - Some Experience and Questions", prepared for the Tulane University Conference on Management Games, April 1961, W.R. Dill of the Carnegie Institute of Technology, warned:

> "that the extremely high levels of interest and effort reported by the first promoters of games are not inevitable."

In examining the use of games within companies and academic institutions in the U.K. the writer personally found that the main problems were in the initial training of the game organisers and inappropriate use of the time available for gaming. The initial training has

---

10. J.W. Plattner and L.W. Herron. "Simulation: Its Use in Employee Selection and Training." American Management Assoc. Bulletin 20. 1962. New York.

been almost the inevitable cause of the infrequency of use of the technology and its newness. The misuse of time, however, is something that could have been overcome by the reading of what literature is available. Most writers feel, and I agree, that the debriefing session should be given paramount importance in any simulation exercise. This is the time spent either during or at the end of the exercise, examining the decisions that were taken and most particularly the reason for, and the way that the decisions were made. I have found that this time tends to focus the students attention on the learning opportunities of games and reinforces what learning there might have been.

SOCIOMETRIC ANALYSIS

The problem that I have found with the exercises which I personally have run, is the students inability to discuss the human problems involved in a team making business decisions. Most of my participants, whether students or managers, have had a scientific or engineering background. They therefore find that talking about sociological and psychological concepts with incomplete

commensurability is difficult.

To overcome these problems I have introduced the use of sociometric scales during the decision-making phase of the exercise. These scales are filled in by each participant after each decision, while the umpires are scoring the decision. By analysing these scales and graphically presenting the objective form of information which they show, I have found that "hardened" engineers are willing to discuss sociological concepts which they felt were beyond their grasp. I have also found that these scales are most helpful to the umpire in deciding which teams need his particular help and when a de-briefing session would be most valuable. Below I include my first, and my most recent sociometric scale (which I am now using). Although the new scale is more sophisticated than the ones I started using five years ago, I find that participants do not object to the time used in filling it in as it is "umpire time".

SOCIOMETRIC SCALE - FIRST FORM

TEAM QUESTIONNAIRE

MEMBER'S No: TEAM: QUARTER: YEAR:

Rate from 0 (worst) to 9 (best) the following:

The morale of your team now _____

The future business prospects of your team _____

Your opinion of your formal leader _____

Your assessment of other teams' opinion of your team _____

The organisation of your team _____

If you were to select a leader now, whom would you choose? Write down his number only. _____

These people have influenced:-

These people

TEAM MEMBER NO.	1	2	3	4	5
1.	X				
2.		X			
3.			X		
4.				X	
5.					X

Please put ticks in the appropriate squares.

SOCIOMETRIC SCALE - PRESENT FORM

Group -------

Period -------

TEAM SCALES

1. How do I feel about this group?

1	2	3	4	5	6	7	8	9
Worst Possible Group				Neither poor nor good				Best Possible Group

2. How clear are the group's goals?

1	2	3	4	5	6	7	8	9
Completely Unclear				Neither Clear nor unclear				Completely clear

3. How did the group work at its task?

1	2	3	4	5	6	7	8	9
Fat and happy - Completely coasting				Neither coasting nor digging				Lean and Hungry - completely digging

4. To what extent was our discussion "up in the clouds" or "down to earth"?

1	2	3	4	5	6	7	8	9
Completely "in the clouds"				In the middle between clouds & earth				Completely "down to earth"

5. To what extent did we talk about our own functioning here and to what extent did we talk about other topics?

1 2 3 4 5 6 7 8 9

Completely outside problems or topics — Both about equally — Completely ourselves and our own group

6. To what extent were group members out to win their own points during the discussion?

1 2 3 4 5 6 7 8 9

Completely out to win own point — Equally out to win point as to consider merits of issue — Completely considering merits of issue

7. To what extent did I have private thoughts, unspoken reservations, or unexpressed feelings and opinions that I would not have felt comfortable bringing out into the open? In other words, was I levelling with the group? I felt:

1 2 3 4 5 6 7 8 9

Completely under wraps closed & hidden — Neither under wraps or free & expressive — Completely free & expressive open & eager

8. To what extent did I feel identified with the group fully "joined up" as a member? I felt:

1 2 3 4 5 6 7 8 9

Completely negative, withdrawn, bored or rejecting, not joined up - out. — Neither in nor out — Completely involved, positive, joined up - in.

9. Did you get help as needed from others during periods of frustration, conflict or personal stress?

1 2 3 4 5 6 7 8 9

No, they disregarded my needs completely. — Neither disregarded nor recognised my needs — Yes, they recognized and met my needs in a completely satisfactory manner.

If the results of these scales are tabulated, they become most useful during the debriefing session. It gives the participants specific values to lead in their discussion of the human interaction in the team. In a sense, part of the potential benefit of a T group session is also gained. A group of business people have been seriously discussing a business problem and are then analysing their reactions to one another. The difference here is that the T group is programmed as to the subjects for discussion and the time allowed for discussion.

GAMES ARE NOT A TRAINING PROGRAMME

The last problem which I have found is that some trainers tended to use a management game as a training programme. It is not a training programme in itself. What then constitutes an executive development programme and how do management games fit into the programme? I make two fundamental assumptions about management in devising an executive development programme. Firstly, no training programme can produce managers. The development of a manager depends as much - perhaps more - on the organisation within which he works as it does on any development programme.

Secondly, the function of a training programme is to provide a sound, rigorous, analytical approach to the problems of management.

The acceptance of these two assumptions leads to a whole range of consequences for the organisation of any development programme. The first means that such a programme will not attempt to encompass everything. The second assumption leads to the abandonment of the 'fragmented' approach to management. We no longer try to train our managers as better accountants or statisticians (assuming this is their prior training). Instead we integrate these specialist approaches by focusing on the two prime ingredients of the management process itself - management decision-making and management behaviour.

Programmes should stress the development of orderly, rational problem-solving ability. The development of this ability must be the core of any professional education, as any engineer, lawyer or accountant would admit - but this recognition is new in management education. This alone is not sufficient; we must also provide analytical tools which will enable the manager

to make better decisions. The trainees must be given a thorough grounding in those tools which are most appropriate to managerial decision-making. Decision-making is, of course, not enough. The manager works through people. For this reason the programme should also stress the implications and possible consequences of managerial behaviour.

The writer accepts the fact that he is not able to teach men to 'handle' other men - to win friends and influence people. He aims instead at enabling them to think clearly about the organisational structure by which, and through which, decisions are affected.

Webb and Weeler wrote about the use of games in their courses or conferences:[11]

> "One of the most serious disadvantages of the short course or conference on management subjects is the limited success achieved by audiences in grasping the implications of what they are told. Among the implications most often missed are those which concern practicalities in the application of

---

11. P.C. Webb & G.E. Weeler. "The Simulation of Management Problems". Journal of Scientific Business, Volume 1, No.2. 1963.

> techniques, in particular those (typical of management problems) in which some degree of conflict of ideas or interests is present, and in which the results may be affected by interactions of competitive and random influences. Such complexities make it difficult to achieve very useful results by lecturing techniques or even by the use of syndicate discussion of case studies, however carefully written; in fact it is likely that a proper understanding of practical difficulties and implications of management action can be obtained through personal experience of situations in which decisions have to be made and evaluated in an actual business environment; that is, by trial and error."

To accomplish these aims the trainee must participate and be highly involved at every stage of the programme. If you want a trainee to learn to use analytical tools in solving management problems, an

excellent way of doing it is to put him in a simulated management environment (a game) where these analytical tools are required; the game through creative participation will forcefully demonstrate its usefulness. This way the trainee not only learns the logic behind the technique, but has actual experience in its use. If you want the trainee to learn how various organisational patterns or behaviour affect a management group, it is essential to have the group solving a business problem as in a management simulation.

C H A P T E R 4

TYPES OF GAMES

Games can be divided into a number of different pairs. For example:

Interacting and Non-interacting

An interacting game is a game in which the decision of one of the participants strongly affects the results of all the other participants. This type of situation normally requires a marketing element to be incorporated in the game. Non-interacting games are games in which one teams' decisions influence only their own activities. These games are usually restricted to the production aspects of management. The competition in this case is only "blackboard" competition, e.g. to see which team gets the best results at the end of the exercise. Although participants examine the results of their competitors in an interacting game, the results show in many ways other than the final total figures put on the blackboard.

FUNCTIONAL AND TOTAL ENTERPRISE

Functional games deal with only one aspect of management, for example, finance, or sometimes even only one aspect of a function of management, such as investment analysis. Total enterprise games deal with all functions of management in a more general way. Sometimes the total enterprise game will strongly stress one aspect of management such as marketing, but will bring in all the other elements to demonstrate their interaction.

GENERALISED AND SPECIFIC INDUSTRY

Generalised Games - The first games written, for which the programmes were available, tended to deal with no specific industry and certainly with no specific product. We saw products being produced such as widgets or grimlets. They tended to be used in a university environment where reference to a specific industry was not necessary. Specific Industry Games were a later development as more and more business firms became interested in using simulations in their executive

development programmes. They tended to relate the games to the industry in which they were involved. Some of the early ones dealt with the distribution of petrol, with insurance, and with plumbing fixtures. From an academic point of view, the problem with these specific industry games is that very often the models within them were considered by the manufacturers to be of a proprietary nature and in not wanting their competitors to get the programme, they prevented academic use of the programmes as well.

The last major distinction between types of games is based on the way in which they are marked, that is hand-operated or computer-operated. This will form the basis of the next chapter.

COMMUNICATIONS GAMES

One of the chief difficulties confronting the designers of management simulations is to determine how much realism to strive for in the exercise. It is most difficult to decide how much to build in as it is possible that a quite artificial environment can be tolerated if the participants can develop enough empathy

for their activities, as in a Greek tragedy where the enthusiasm of both player and audience transcends the physical limitations of the setting.

One of the areas where games with an artificial environment are most frequently used is in demonstrating the effectiveness of communications patterns and in encouraging students to discuss the difficulties which they have in communications. It has been found that this is an area where most people inherently believe they have some ability and therefore getting them to discuss the problems which they face had proved extremely difficult.

A number of games were devised based either on Scrabble or on multiple sectioned square cards. In either case, either the letters which made words or the patterns of card which would form a square were passed from participant to participant through a series of formal communications networks established by the teacher. At Manchester we found several restrictions to the usefulness of existing games. One was the lack of complexity which meant that only simple communications

patterns could be studied, and the second was that the solutions proved so simple for the brighter student that the problems of the communication patterns were not clearly demonstrated.

To solve this I developed in conjunction with Professor R.W. Revans the M.I.S.T. Communication Game. This game is based on unique prime numbers, that is a prime number which cannot be turned into another prime number by rearranging the order of its digits. As there are twenty-one such three digit numbers, we found that this exercise allowed ample scope and severity to develop the participant reaction which was desired.

M.I.S.T. COMMUNICATIONS GAME

THE UNIQUE THREE FIGURE PRIMES

1. Below is a list of the 63 cards necessary to play the game.

Table 1

103 blue	409 brown	601 green
109 brown	431 yellow	607 brown
257 orange	487 blue	809 yellow
263 red	503 orange	827 blue
269 black	509 red	829 orange
307 violet	523 black	853 red
401 green	541 violet	859 black

2. Each of these numbers is one of the 21 unique figure primes. A unique prime cannot be turned into another prime by rearranging the order of its digits.
3. A table of three digit prime numbers takes about ten minutes to search so as to extract the unique primes. If this extraction is not made, it is very easy to mistake many primes for unique primes, especially when doing other things with the numbers as well.

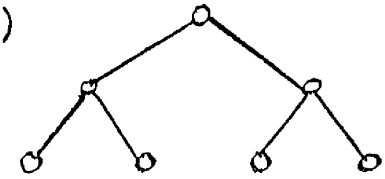
SUBSETS

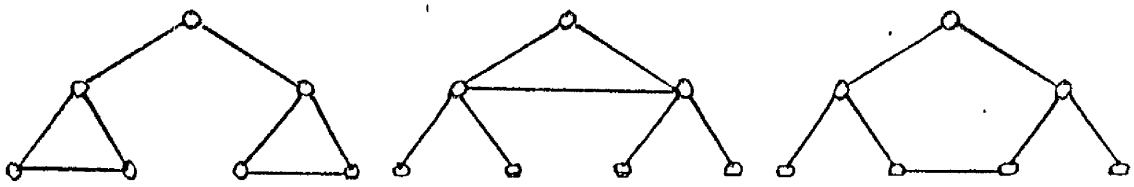
4. Sets of say, 5 unique primes can be drawn from Table 1 in many ways. They can be of unique primes preserving the colours of Para.1 or they can be scrambled by drawing cards of different colours but with the

appropriate digits on them to assemble into any unique prime irrespective of colour; a set of eleven is obtained by leaving out all unique primes containing a zero, and so forth.

5. Four sets of 5 primes, or three sets of 7 can be drawn, making group competition readily possible. In such groups it would be necessary to keep to the colours of Para.1.

6. Complex groups, such as (a) demanding 7 players, could compete against each other. So also could groups in which short circuiting was allowed, such as:





RULES

7. All players start with three random cards and a table of all three figure primes. They are also given a definition of a unique prime.

8. (a) Players may send both their needs in writing alone and their offers in written form or the card offered itself. They mustn't at any time hold

less than two cards.

(b) Players are not allowed, at any time, to declare to others what cards they actually hold.

(c) No single note may refer to more than one card.

9. Communications are permitted only with persons nominated according to the structure of the exercise.

10. CONFERENCES

At any time after the first fifteen minutes play a group may call one Conference of its own members if it so wishes; time consumed at this Conference will be doubled when added to playing time in reaching the total time taken by the team to achieve its goal. At this Conference there must be no discussion of particular cards or sets of cards. The group holding the Conference can make any general rules that do not violate Rules 7, 8, 9 above.

11. An example of a general rule might be:

"In games played under "military" structures, (e.g. Para.6 a.) players in superior positions may issue instructions to subordinates to pass forward

particular cards; subordinates may in turn, need to extract these cards from still lower ranks."
(Such instructions may at times be meaningless because the subordinate does not hold, nor can he get, the card demanded by his superior).

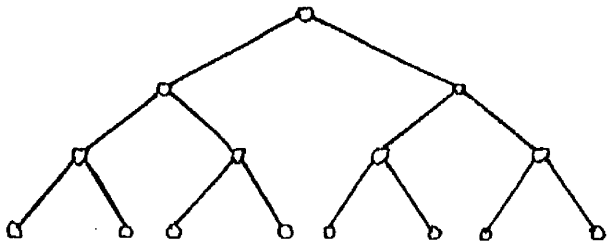
12. Another example of a general rule might be:
"The group may form a working party to extract, list and make available to all its members all unique three figure primes defined under Para.2."
(Such activity, not being part of the game played under Rules 7, 8 or 9 would be regarded as part of the Conference and the time it consumed would count as double in assessing the final performance of the group).

OBJECTIVE

13. The objective of the exercise is for each member of a communications network to have in his possession three digits which together comprise a unique prime number.

FUTURE DEVELOPMENTS

14. It is possible to build with this set of cards a very elaborate structure such as (b) involving 15 players. If one man in this knew at the start both the selected set of 15 unique primes and the starting positions of the 45 cards randomly scattered through it, how effective is it for him to be placed in different positions?



With general rules he could issue instructions demanding such and such cards from some subordinates and oblige others to accept so and so in return, etc. The management analogue is that of the man with a policy that he is trying to get others to adopt. He is still restricted to one reference per message and cannot leap over subordinates' heads.

TABLE OF 3 DIGIT PRIME NUMBERS

101	179	263	353	443	547	641	739	839	947
103	181	269	359	449	557	643	743	853	953
107	191	271	367	457	563	647	751	857	967
109	193	277	373	461	569	653	757	859	971
113	197	281	379	463	571	659	761	863	977
127	199	283	383	467	577	661	769	877	983
131	211	293	389	479	587	673	773	881	991
137	223	307	397	487	593	677	787	883	997
139	227	311	401	491	599	683	797	887	
149	229	313	409	499	601	691	809	907	
151	233	317	419	503	607	701	811	911	
157	239	331	421	509	613	709	821	919	
163	241	337	431	521	617	719	823	929	
167	251	347	433	523	619	727	827	937	
173	257	349	439	541	631	733	829	941	

C H A P T E R 5

SCORING

HAND AND DIGITAL COMPUTER SCORED

With one exception*, all games that have been developed so far by others and are known to me were written for calculation by hand or using a digital computer. Clearly, each of the systems has disadvantages otherwise all games would have been written in one medium or the other.

"Manually computed simulations are used when:

1. A computer is not available when needed.
2. The use of a computer would be too costly.
3. The location of the educational programme makes the use of a computer inconvenient.
4. The complexity of the simulation and the feed-back reports do not involve large amounts of data.
5. Certain desired learning values exist in having the participants do a part of the

---

* The exception is ASCOT (Analogue Simulation of Competitive Operational Tactics) which was developed by Patrick J. Robinson for the Market Research and Operational Research Division of Imperial Oil Limited, Toronto, Canada. This game was used during his stay in the Company from 1959-60, but was abandoned at that time when he left.

computational work, as, for example, in preparing financial statements.

6. The simulation operation is non-continuous, and there is no great pressure of time between periods of play.

When such conditions do not exist, then a computer is generally used. A computer offers advantages of speed in computation, a high degree of accuracy, and greater neatness in reports produced.[12]

Briefly the disadvantages which I found are as follows:

FOR COMPUTER GAMES

1. Cost - a comprehensive game takes about six months to one man year to programme, as well as the use of a very expensive asset while the game is being played.

2. Immobility - If you use a digital computer game, it is essential that the play takes place near the machine so that the results can be given back to the students as

---

12. J.W. Plattner and L.W. Herron. "Simulation: Its Use in Employee Selection and Training". American Management Assoc. New York, 1962.

quickly as possible. This means bringing all the play to where the machine is, and very often you find that the physical facilities are totally inadequate in computer machine buildings. This, of course, can be overcome in the university environment.

3. Rigid Kriegsspiel - because of the enormous complexities of trying to build any programme adaptability in devising a computer programme, it is generally the case that game programmes are completely rigid. This means that any new ideas or new thinking brought up by the participants is unacceptable within the structure of the exercise.

FOR HAND OPERATED GAMES

1. Errors in grading - simulation models are usually relatively complex; errors can come into the scoring procedure. If one of these errors is critical, it tends to detract from the credibility of the exercise.

2. Time and complexity - it is essential in any learning situation that the evaluation of a student's performance be as quick as possible after the end of that performance.

In management simulations this is particularly true as a lengthy interval between decision taking and feed-back can lead to a loss of interest by the participants. With hand operated games umpire time increases geometrically with complexity and sometimes reaches two hours.

3. Lack of verisimilitude - it is particularly important when using simulations in industry that the executives feel that they are participating in a business situation. The "aura" of a computer seems to provide this.

ANALOGUE SOLUTION

In addition to these problems a major problem which I encountered was the inability of management teachers to communicate with one another, either the games which they had written or the best way in which those games could be used for teaching. With hand operated games the marking tended to be complex and not properly documented. With computer games, at any level of sophistication, they tended to run only on one model of computer. In addition, often the model needed several

special options included to get a game programme to work.

Clearly a very small portable and cheap analogue computer would solve the majority of the problems listed:

1. Cost - the cost of the newly designed machines is about £100. and could therefore be allocated entirely for use in simulation within a management department.

2. Immobility - the machine as built weighs 10 Kilograms which is quite handy, but this could be reduced to about 2 Kilograms at a small increase in cost, and a large increase in accessibility to programme cards.

3. Rigid Kriegsspiel - the machines prggramme can be changed at any time by the addition or deletion of programme cards, or by superimposing hand operated elements. This super-imposition is easy as the umpire has complete control of the programme at all times.

(1^1) Errors in grading - These are reduced to $\pm$ 1% which is negligible within the simulation context.

(2^1) Time - As the decision variables are fed into the machine directly through potentiometers which eliminates the need for all card punching, time is equal to a digital computer.

(3^1) Verisimilitude - the aura of a computer is present.

ATHENA

The analogue computer which was finally developed is called ATHENA (The Greek Goddess of Wisdom, Industry and Prudent Warfare). In ATHENA each element in a management game is expressed as a mathematical equation either in numerical, graphical, or chart form. These mathematical expressions are represented by a programme card in ATHENA, and programming a game merely requires the insertion of the appropriate cards (i.e. mathematical expression) into the computer. The game is then balanced by the use of multiplication switches, which amplify the important elements and diminish the less important elements.

The features of ATHENA include:

10 Interacting Variables representing any functions (positive or negative or a combination thereof)

10 Non-interactive Variables.

Multiplier circuits to increase the importance of any variable (e.g. where this is more than one market, the effect of trained salesmen may be different in importance between markets or where

there are a number of outcomes from the same set of decisions, the importance of one or more variables may be adjusted for each outcome, as in a Personnel Game, where the effect of spending money on safety would be far more important in determining Accident Rate, than in determining Turnover Rate).

Direct input through 10 turn Potentiometers for ease of operation.

Fixed Effect Switch - to allow a permanent or semi-permanent positive or negative effect from some action which the team under examination has taken (e.g. a change on the method of distribution or a new product development). This adds or subtracts from the total index score given in the voltmeter.

Direct Readout through a Voltmeter or Digital Voltmeter.

Immediate interchangeability of programmes for ease of operation of any one game or to allow any user to write or change programmes from his first understanding of the computer.

Portable.

Any function can be created on a card and added to the users programme library for a nominal cost.

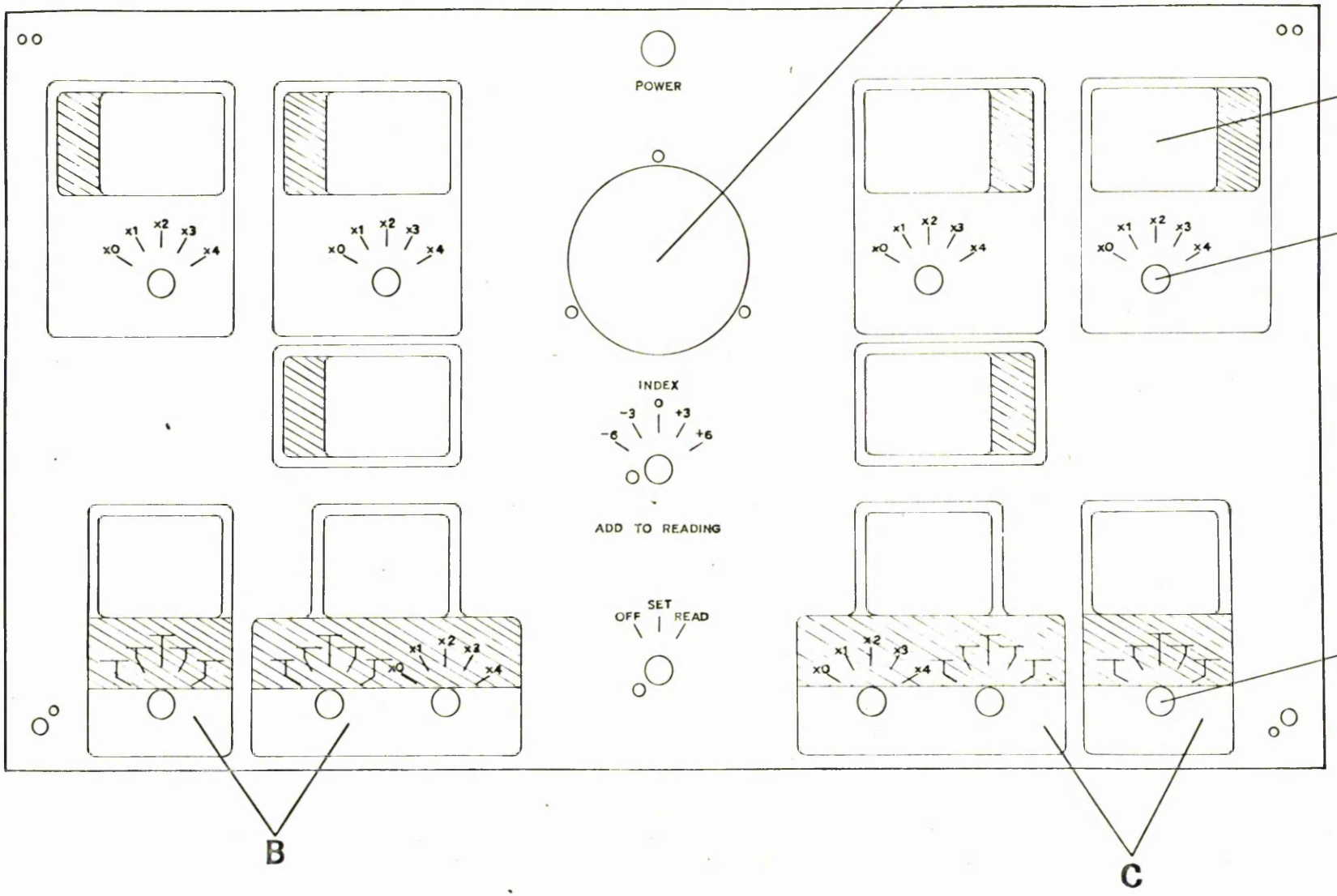
In the diagram of the operator's console can be seen all the key elements:

a) Voltmeter or Digital Voltmeter.

b) Simple Curve Exponential functions positive and negative.

c) Straight Line functions positive and negative.

OPERATORS CONSOLE - ATHENA COMPUTER



d) Potentiometer Location.

e) Multiplisation Factor.

f) Function Selection Switch (This is used only on Straight Line and Simple Curve Functions which has five functions per card. This allows the umpire to increase or decrease the effectiveness of any variable, during the exercise).

All hatched areas are roughened for writing notes on with a pencil. Six potentiometers not included in the groups B and C can be used for any shape of functions. A number of these are included in the Appendix as examples. The "add to reading" switch is used for adding or subtracting any permanent effect to the score of any team. The ~~potentiometers~~ voltmeter either yield an answer in quantities (units or pounds shillings and pence) or in an interacting game, it yields an index of the competitors to determine, for example, - the share of market achieved.

I have used ATHENA over 100 times and have carried it with me to all courses where it has been used. Very often it has been shipped by British Rail or B.E.A. and

it has always worked immediately without failure. The secret to this and to its low cost and weight is the elimination of all amplifiers. The way this is done is explained in detail in the patent specification enclosed in the appendices. However, I will describe it briefly below:

To find any point on a Straight Line or Simple Curve requires only the turn of the potentiometers to the value required. In the past it has been felt that to find values in complex curves such as those in the Appendix (which are always required in management games) required the use of numerous amplifiers. I have overcome this need by using a tapped potentiometer. The potentiometer has 8 equally spaced taps which it crosses during its 10 turns. A resistance can be placed across each of these taps to change the direction of the curve from the point of the tap onwards. Therefore a compound curve with up to 8 changes of Straight Line direction can be built up in each potentiometer. To the operator using the potentiometer the manipulation is exactly the same as that of a Straight Line Function. The resistors are placed on a plastic card with multiple

gold contacts which automatically upon insertion place the resistances across the taps. This means that the programme in the machine can be changed simply by lifting the lid and inserting a new series of cards to represent new functions. Each function represents one element of the programme model such as, a cost curve, a demand curve. As an example:

Function 5 (in the Appendix) could represent advertising effectiveness where the effect of over advertising is negative. Function 5A could represent the values of expenditure on production engineering where low expenditure yields little result and extreme expenditure yields little incremental result. 6A could represent a demand curve and Function 6B could represent a total cost function where 5 on the X scale is optimum production level.

It will be seen from the simplicity of the machine, the ease with which these games can be programmed for it, and most particularly this programme information transmitted. If this were done, management trainers would have a common background of knowledge to use in

their discussions at meetings. and in papers. I have also programmed games in the area of the social sciences on this machine and its use in this area could be equally as important as in the area of management games.

BRACE

When ATHENA was first built I decided to build a fairly complex game model and programme it on the machine. I felt that this would allow me, by stretching the limits of the machine, to test its fullest capabilities.

As the British Institute of Management had requested a game of this complexity for their Bristol conference I wrote a game based on work that was being done at the Bristol Aeroplane Technical College. The game is called "BRACE" (BRistol Aeroplane Computer Exercise). I include the outline of the game below to indicate its scope.

With ATHENA two umpires can deal with four "BRACE" teams in a 15 minute scoring cycle. Without ATHENA 5 umpires take just over an hour.

B R A C E

BRISTOL AEROPLANE COMPUTER EXERCISE

1. THE OBJECTIVES

The Management Decision Exercise is used to simulate the organisation and management functions of a simple enterprise making one product and selling in predetermined markets in direct competition with several identical companies.

The exercise involves the basic functions of management, i.e. Marketing, Research and Development, Production, Finance and Advertising.

The exercise is not intended to teach any specific lessons about the production and marketing of Packaged Power Plant Units. Rather it is the intention of the organisers that the participants should be placed in a highly involving learning environment in which they will develop the analytic skills necessary to be able to solve, in their own jobs, the types of management decisions created by this exercise. Further it is their intention that the participants, by introspecting into their own behaviour and that of the other members of the group, learn about the processes of decision taking.

2. THE PRODUCT

Each company manufactures Packaged Power Plant Units. These are transportable diesel engined power plants producing 50 K.w. The selling price is fixed initially at £2,500 per unit.

3. THE COMPANIES - ORGANISATION, CONTROL AND RECORDS

a. Organisation

The Company members can organise themselves either as a management committee, or delegate specific functions to individuals. However, the form of organisation selected and the changes thereto should be communicated to the Controller.

b. Control

The Controller is responsible for the operation of the exercise and for the issue of further capital.

The model of the market within which you will operate is built as a series of mathematical expressions in the ATHENA Analogue Computer. Your decisions will be fed into the computer, and it will decide the allocation of market shares. The model will not change during the course of this exercise and you will therefore, by careful analysis, be able to learn a great deal about the environment in which you are operating and make better decisions as the exercise progresses.

c. Records

i. Decision Form

Each Company enters its decisions quarterly on a decision form, i.e.

-Amount spent on advertising in each Sales Area.

-Selling price per unit in each Sales Area.

-Research and Development, and Personnel and Welfare Investment.

-Sales force adjustments.

This form is handed to the Controller who will later return it showing the quarter's trading results, together with any penalties that may be imposed.

ii. Operating Statement.

Each Company prepares a quarterly operating statement which includes a statement of Costs; W.I.P. and Stock Position; A Cash Statement; A Trading Profit and Loss Account, and a Balance Sheet.

iii. Annual Balance Sheet and Policy Statement

At the end of each financial year each company will complete a Balance Sheet and Policy Statement; the latter will indicate how the company proposes to operate during the ensuing year. This combined document is published and available for general distribution.

4. FINANCE

a. Commencing Capital for each Company

i. £200,000 Ordinary Shares.
ii. £50,000 10% Cumulative Preference Shares.
iii. £50,000 8% Debentures.

b. Further finance can be arranged through the Controller if a suitable case is made.

c. Costs

i. The initial production line, capable of producing 20 units per quarter, has a capital cost of £150,000.

ii. Indirect Costs for the initial production line are £10,000 per quarter.

iii. Direct Costs for the initial production line are £400 per unit per quarter, i.e. £8,000 per 20 units per quarter.

iv. Information on the Capital Costs and Operating Costs of additional lines of production is given in BRACE Appendix I.

5. PRODUCTION

a. Initial Plant - Sequence of Operations

The following sequence of operations appears diagrammatically in Appendix BRACE II.

i. First Quarter

Work starts on Plant construction.

ii. Second Quarter

Plant construction is completed and Work Scheduling begins. The Company now bears £10,000 Indirect Costs.

iii. Third Quarter

Manufacture begins and 20 units of Work in Progress now appear in Production. The Company now bears £10,000 Indirect Costs and also £8,000 Direct Costs.

iv. Fourth Quarter

The Third Quarter's Work in Progress is completed and transferred to Stock and is now available for sale. A further 20 units Work in Progress appear in Production.

b. Additional Production Lines

Additional Production Lines, each capable of producing 10 units per quarter may be laid down at the discretion of the Company. The sequence of operations is the same as for the Initial Plant.

c. To Suspend Production

The Initial Production cannot be suspended. The Additional Production Lines may be suspended, by giving a quarter's notice to the Controller, but the Indirect Costs of these lines will continue to be debited to the Company Account. To recommence the operation of a production line, a quarter's notice must be given to the Consultant.

d. Carrying Cost

This is equal to 10% of Closing Stock (b) on the Operating Statement. This cost must be added to Total Manufacturing Costs.

e. Changes in Production Level

Production can be decreased by 10% by disregarding the appropriate Direct Costs. Production can be increased by 10% by paying the approximate extra Direct Costs plus a £500 overtime bonus per unit.

6. MARKETING

a. The Market

i. The SALES AREAS are E.E.C. E.F.T.A. including the U.K., and the Commonwealth.

Each area has different Market characteristics and must therefore be treated individually to optimize results. Their reactions to:-

Price
Advertising and Marketing Campaigns
Sales Force Effectiveness,

will vary. To this end the historic and current relationships between England and the Areas should be considered as well as their own state of industrial sophistication. Do not, however, be bound by your own marketing experience of your own product. This is a unique product and therefore once the effect of your initial action is available, careful analysis should be made to confirm or disprove your original market thesis. The total volume of sales may expand or contract each quarter in relation to the market economic situation.

Notice of such changes is given by the Controller.

ii. The Controller may at intervals ask Companies to quote for a fixed-price annual contract.

b. Recruitment, Training and Salary of Salesmen

i. The cost of recruiting and training a salesman is £1,000. He receives a

salary of £250 per quarter.

ii. The salesmen are operative in the third quarter following their recruitment, when they start on commission and salary. Traditionally a universal commission of 5% is paid. There is, however, no reason to believe that this is either right or wrong. Once a commission level is set in a sales area, it may never be lowered. It may be raised during the first quarter of any year. There is no need to pay the same commission throughout the world.

iii. A Company can place its salesmen in any Area it chooses. If, however, they wish to transfer a salesman the moving expense is £2,000.

iv. Salesmen may be dismissed by giving a quarter's notice to the Controller.

v. The efficiency of a salesman improves as he matures in the field. His efficiency can be improved far more rapidly by training after some field service. A training programme lasts for one quarter and costs £1,000 + salary. When the salesman returns to his area his training will increase the general efficiency of the sales force in the area.

vi. Sales force effectiveness is determined by
- the number of active salesmen in the area.
- their average efficiency.

vii. An experienced salesman can be hired away from a competitor if
- in that area your salesmen on average are earning substantially more than he is
- he has a higher average efficiency than in your sales force in that area.

The cost is £1,000 to try and an additional £2,000 if successful.

c. Advertising

There are two basic forms of advertising in this exercise.

a. Prestige Advertising - i.e. advertising the company name and image, public relations work etc.

b. Product Advertising - This is done by direct mail and technical journals. It emphasises product distinction and quality rather than image.

Either or both forms of advertising can be used in any area with no limits.

d. Pricing

The Selling Price is fixed at £2,500 each unit as a result of a Price Agreement between all the Companies. This Agreement ceases from the start of the second year of operation. Prices can then fluctuate up or down and different prices can be charged in the three Sales Areas or the Agreement can be negotiated by all or several teams.

e. Sales

Sales in any Area are allocated to Companies on the basis of:-

i. Price per unit.

ii. Effectiveness of Marketing.

iii. Effectiveness of the Sales Force.

f. Market Research

Companies may engage in Market Research on the payment of a Consultancy Fee. A summary of Consultancy Services and costs is given in BRACE Appendix I.

g. Overselling

If a Company oversells, i.e. makes more sales in a quarter than the number of units it manufactures in that quarter, plus the stock it holds, then:-

i. the unfulfilled sales are lost to the market. The sales lost will be those units bearing the highest price.

ii. a contractual penalty will be imposed of £100 per unit oversold. The Company will enter this amount against "Penalties" in the costs column of the Operating Statement for the quarter in which the overselling takes place.

iii. a loss of goodwill occurs which leads to a reduction in sales for the following four quarters throughout the world. The severity of this penalty will depend on the number and frequency of unfilled orders.

7. RESEARCH AND DEVELOPMENT

a. Companies may invest in Research and Development. The probability of obtaining an Improved Product depends on the annual total cumulative investment in Research and Development, and to be effective a quarterly investment must be maintained.

b. Research and Development may be directed at either

i. Improvements in the product that make it more saleable. or

ii. Improvements to the product that lead to more economical manufacturing processes. This means if a Company gains one Improved Product, it can reduce its Direct Costs by £50 per unit starting in the following quarter. Two Improved Products means a reduction of £100 in Direct Costs per unit. Further Improved Products however must be taken in the form of a more saleable product as described in 7 b.(i).

c. At the start of Research and Development, Companies must nominate whether their investment is direct at (i) or (ii). Companies are allowed to re-direct their Research and Development after giving notice in the Annual Policy Statement.

d. When all Companies have gained Improved Products in terms of saleability, all benefits are immediately cancelled, and efforts start again to obtain Improved Products.

8. PERSONNEL AND WELFARE SERVICES.

Strikes may be introduced into the exercise if wage negotiations between the Company and the Union (Controller) break down. The Unions amicability in settling these negotiations will be determined by the expenditure on Personnel and Welfare since the last negotiation.

After each negotiation a quarterly rate is established and must be maintained until the next negotiation.

BRACE APPENDIX I

SUMMARY OF EXPENSE ITEMS

Production Costs and Investment

i. Plant Investment

1st Production Line	£150,000
2nd Production Line	£ 50,000
3rd Production Line (additional load and building required)	£100,000

ii. Production Lines

A Company may decide to lay down additional lines of production at any time.

The production costs are as follows:-

Prod. Lines	Units per quarter.	Indirect cost per quarter	Direct Cost per Unit	Cost Per Unit
1	20	£10,000	£400	£900
2	30	£12,000	£350	£750
3	40	£14,000	£300	£650

Salesmen

i.	Recruitment and initial training fee	£1,000
ii.	Salary per quarter	£ 250
iii.	Quarterly cost of additional training	£1,000 + salary
iv.	Trying to hire an experienced salesman	£1,000
v.	Additional fee for hiring an experienced salesman	£2,000
vi.	Transfer to new area	£2,000

Advertising

Both prestige and product at your discretion.

Market Research and Consultancy Services

i.	Total potential sales in all sales areas	£5,000
ii.	Revised information on total potential sales in the coming quarter.	£2,000
iii.	ALL Company's share of the Market in a given quarter. Total	£1,000
	Area by Area	£2,000
iv.	Total Research and Development investment of all Companies.	£1,000
v.	Competitor's prices and commission rates for a given quarter.	FREE
vi.	Approximate efficiency of all sales forces in any one area.	£1,500
vii.	Approximate advertising expenditure (both types) by companies inone area.	£1,500
	In all areas.	£4,000

Research and Development

	Minimum investment per quarter.	£2,000

Personnel and Welfare Services

	Minimum investment per quarter.	£1,500

Penalty Clauses

i.	Cashing of Accounts Receivable before due	10%

ii. Delay in rendering Operating Statement:

First time	£ 500
Second time	£1,000
Subsequently -	Geometrically

iii. Overselling - Penalty of £100 per unit oversold.

BRACE APPENDIX II

TIME SCHEDULE OF PROCEDURES FOR FIRST SIX QUARTERS OF EXERCISE

	1	2	3	4	5	6
Costs/ Income	Plant Capital Cost £150,000	Indirect Costs £10,000	Indirect Costs plus direct costs £18,000	Sales Made	Debtors	Collections
Production	Plant Construction Starts	Plant Completed Start work Scheduling	W.I.P. appears in Production	Stock Available for sale.		
Salesmen		Recruit £1,000	Train £250	Operational £250 plus Commission.		

MANAGEMENT DECISION EXERCISE - BRACE

DECISION FORM 1

TEAM: QUARTER: YEAR:

	E.F.T.A.	COMMON MARKET	COMMONWEALTH
PRICE OF PRODUCT			
PRESTIGE ADVERTISING			
PRODUCT ADVERTISING			
EFFICIENCY OF SALESMEN			
COMMISSION RATE			
NUMBER OF ACTIVE SALESMEN			

The Quarter which we last OVERSOLD was _____

The Number oversold was _____ units.

The Number of product saleability improvements (if any) we have is _____

MANAGEMENT DECISION EXERCISE

BRACE - DECISION FORM 2

TEAM: QUARTER: YEAR:

UNTRAINED SALESMEN REQUESTED _____

SALESMEN IN PRE-SALES TRAINING _____

SALESMEN ASSIGNED TO POST-EXPERIENCE TRAINING _____

ACTIVE SALESMEN _____

EXPERIENCED SALESMEN: E.F.T.A. _____ COMMON MARKET _____

COMMONWEALTH _____

SALESMEN LOST TO COMPETITORS: E.F.T.A. _____

COMMONWEALTH _____ COMMON MARKET _____

TRANSFERS _____

DISMISSALS _____

PRODUCTION IN UNITS _____

PLANT CAPACITY _____

NEW CAPACITY ORDERED _____

NEW CAPACITY AVAILABLE IN QUARTER _____

R + D - PRODUCT SALEABILITY _____

R + D - MANUFACTURING EFFICIENCY _____

PERSONNEL AND WELFARE _____

MARKET RESEARCH

i. Total potential sales in all Sales areas for the coming year _____

ii. Revised information on total potential sales in the coming quarter _____

iii. ALL Company's share of the Market in a given quarter. Total _____

Area by Area _____

iv. Total Research and Development investment of all Companies _____

v. Competitor's prices and commission rates for a given quarter _____

vi. Approximate efficiency of all sales forces in any one area _____

vii. Approximate advertising expenditure (both types) by companies in one area _____

in all areas _____

PENALTIES

CASH ACCOUNTS RECEIVABLE _____

DELAY IN RENDERING OPERATING STATEMENTS _____

OVERSELLING _____

MANAGEMENT DECISION EXERCISE

B R A C E

COMPANY

ANNUAL BALANCE SHEET AS AT END OF YEAR ____

AND POLICY STATEMENT

BALANCE SHEET

LIABILITIES		ASSETS	
Share Capital Issued-		Plant	--------
10% Cum. Pref. Shares	-----	Work in Progress (D)	------
Ordinary Shares	-----		
TOTAL	-----		
Profit/Loss A/C Bal. (+ or -) (G)	-----	Stocks (B)	------
BALANCE	-----	Debtors (sales outstanding)	------
8% Debentures	-----		
Bank overdraft, etc.	-----	Cash (F)	------

POLICY STATEMENT

BRISTOL AEROPLANE COMPUTER EXERCISE

MANAGEMENT DECISION EXERCISE

OPERATING STATEMENT

COMPANY ..... QUARTER ..... YEAR .....

COSTS

Indirect Costs .....
Direct Costs .....
Total Manufacturing Costs .....
Recruiting .....
Salaries .....
Advertising .....
Consultancy Work .....
Research & Development .....
Personnel/Welfare .....
Factoring .....
Penalties _____
Total Costs (E) _____

W.I.P. AND STOCK

W.I.P.	Units	Value (at Manufacturing Cost)
Opening W.I.P. (C)		
Production		
TOTAL		
Transfer to Stock (H)		
Closing W.I.P. (D)		

STOCK	Units	Value (at Manufacturing Cost)
Opening Stock (A)		
Transfer from W.I.P. (H)		
TOTAL		
Less Sales		
Closing Stock (B)		

CASH STATEMENT

New Capital
overdrafts, etc. .....
Opening Balance .....
Contracts .....
Collections (Sales paid) _____
TOTAL .....

Less –

New Plant
Investment .....
Costs (E) .....
Dividends on Pref. Shares .....
Dividends on Ord. Shares .....
Interest on Debentures .....
Interest on Bank O'draft .....
Repayment of O'draft etc. _____
Closing Balance (F) _____

TRADING PROFIT & LOSS ACCOUNT

Sales this quarter
(at full value) .....

Less –

Total Costs (E) .....
Increase/Decrease in Stocks and W.I.P. (D – C) + (B – A) .....
Cost of Sales _____

Trading Profit/Loss for quarter .....

Deduct: Dividends & Interest Payments _____

Net Profit/Loss for Quarter .....
Cumulative Profit/Loss (b/f) _____
Cumulative Profit/Loss (G)(c/f) _____

C H A P T E R 6

A HAND OPERATED GAME

This chapter is basically a hand operated business game. I wrote this game in co-operation with the participants at the Business Games Seminar in Lausanne April, 1962. I and Clive Lovelock led this conference for the European Association of Management Training Centres. The game is most valuable because it demonstrates what I consider to be the most advanced and useful form of hand operated scoring - the normograph. In addition to the players instructions all the normographs and umpires rules are included so that the game, can be used by the reader if so desired.

I have played this game with about 20 groups of students or managers and it has been changed quite substantially since written at Lausanne. In its final form, as presented, I feel it is one of the most useful techniques for demonstrating, and stimulating discussion, on the job and role of the marketing manager.

LAUSANNE MARKETING GAME

UMPIRE'S NOTES

1. General

This simulation is an interacting hand operated game which incorporates some lag and decay effects as well as non-linear relationships. Mathematical equations are not used; relationships are expressed graphically.

2. Purpose

The purpose of the game is to acquaint the student with the so-called 'marketing mix', that is, the interplay of 'internal' factors, such as

- advertising
- sales promotion
- product policy
- pricing policy
- channels of distribution

as well as 'external' factors, such as general market trends, and competitor action. The goal of the marketing manager should be to achieve a 'mix' of controllable factors, which is optimal in terms of the goals of the firm.

3. Goal

The goal of the game can be undefined or specified as follows:

Profit is to be maximised

4. Description

Each team represents a company manufacturing a consumer good of semi-durable nature competing in the same market. Each team commences play with cash on hand amounting to $20,000 (or referee's discretion).

The decision period corresponds to a 'real' business quarter. The quarter was selected so that seasonal fluctuations in total demand could be incorporated, giving the latter a cyclical nature which could be discerned by the astute player.

Teams are called upon to make the following decisions:

a. Amount of money to be spent on Advertising:

i. Amount of money to be spent on "Newspapers"

ii. Amount of money to be spent on "Magazines"

iii. Amount of money to be spent on "Radio and T.V.

(The allocation of the total sum spent on advertising is of considerable importance, since the three media exhibit different effectiveness curves)

b. Amount of money to be spent on Product Development:

The company may choose to spend sums on product development, which includes questions of design and/or packaging, as well as any other 'real' or 'fictitious' innovations capable of securing, for the innovator, a competitive advantage.

c. Sales Price

The company must set its selling price to retailers. The demand curve is of classical form; however, it incorporates the "inferior goods effect", wherein an unreasonably low price causes demand to respond negatively.

d. Sales Promotion

The company must decide what amount will be spent, in each period, on sales promotion.

e. Channels of Distribution

The company must, at some point, decide which of two alternative distribution channels it wishes to use:

i. Wholesalers: This is the distribution scheme used at the outset of the game.

The wholesaler takes 15% of $ sales volume as his commission.

ii. Direct Distribution: At the beginning of the third period, teams will be offered the opportunity to purchase information relative to distribution. They will be 'sold' two points of a cost/quantity (units) relationship. This cost curve will be such that the 'wholesaler' is favoured at low volumes, while direct distribution is more 'efficient' at higher volumes.

f. Amount to be spent on the purchase of additional information.

5. The Relationships (All relationships are described in terms of cost/effectiveness)

a. Advertising

As stated above, the effectiveness curves of the three media are of different shape, but the shapes of these curves are unknown to the players. They may 'purchase' from an 'outside consultant' three points of every curve (non linear).

Lag Effect: Advertising incorporates a 'lag effect'. This is administered by granting only half of the effectiveness purchased to the period for which the expenditure is made, whereas the other half of the effectiveness is carried forward to the next period.

b. Product Development

The 'Product Development' cost/effectiveness function is of a stepped nature. Outlays are cumulative over time, and when a minimum of $10,000 is attained, effectiveness goes up to the 'step'. The surplus over $10,000 is carried forward, serving as the basis for a new cumulation leading either to 'step 2' or the re-attainment of 'step 1' (if decay is more rapid than new funds allocated to product development).

Decay: We have incorporated decay into effectiveness gained through new product development. Effectiveness gained is 'amortized' as follows:

Period in which 'step' is attained:	5/5	effective
" t + 1	4/5	"
" t + 2	3/5	"
" t + 3	2/5	"
" t + 4	1/5	"
" t + 5	0/5	unless cumulative outlays have again attained $10,000.

c. Pricing

This is straightforward, with no lag or decay effects.

d. Sales Promotion

The sales promotion function actually comprises two cost/effectiveness functions of the same shape. The 'higher' (more effective) of the two is used in cases where the company uses direct distribution, while the 'lower' function is used in cases where the wholesaler is used. The rationale here is that company salesmen will exercise more 'push' to a sales promotion scheme

than will a similar programme administered by the wholesaler.

e. Distribution Channels

As mentioned, the game starts at a low 'total market' state, thus making wholesaler distribution more effective. This is the 'status quo' at the outset, and, indeed, companies do not at this point know of the direct distribution alternative. Information pertaining to direct distribution cost relationship is 'sold' at the beginning of the third period.

Note: As stated above, switching to direct distribution will permit the firm to benefit from higher effectiveness in Sales Promotion.

Note: Once the decision is made to change to direct distribution, the firm is committed to this alternative. A return to Wholesaler Distribution is not possible. Thus, in making this decision, players must weigh possible savings from direct distribution over time as opposed to possible higher costs incurred in case of sales declining below the direct distribution/whole-

saler break-even point.

6. Information Which May be Purchased

The following information is available to teams:

a. Information on Media Effectiveness

Any time after the beginning of period 3, teams may purchase three predetermined cost/effectiveness points of one, two or all of the media effectiveness curves. The points are those indicated on the "Advertising Effectiveness" graph.

Prices:

$10,000	for	3	points on	Newspaper curve
$10,000	"	"	"	Magazine curve
$10,000	"	"	"	Radio curve

Referees may or may not offer a 'package' of all nine points for a sum somewhat less than $30,000.

b. Information on Direct Distribution System Costs

At the beginning of period 3, teams are offered two points on the direct distribution cost curve. The two points to be sold are indicated on the

"Distribution Cost" curve.

Price: $10,000 (or referee's discretion)

7. Information given to teams at no cost, at end of each period.

The following information is given to teams at the end of each period:

a. Total industry sales.

b. Team's market share.

c. If enough referee manpower is available, referees may compute number of units.

d. Unit production cost, if different from standard.

8. Production and Production Costs

Production costs are constant at $100/unit.

The game may easily be modified, by the referee to increase unit production cost at very low volumes.

9. Total Market

The total market potential is predetermined and is given to seasonal variations with an annual (four quarter) cycle. The graph additionally furnishes an upper and lower limit of possible fluctuations. If all teams spend large sums of marketing effort,

the referee may add up to 10%.

If all teams' marketing effort is average, the referee may use the centre of the 'trend band'.

If total (all teams') marketing effort is low, the referee may deduct up to 15%.

The actual quantitative definition of 'high', 'average' and 'low' total effort is best determined empirically.

10. Computing Results.

The 'effectiveness' attained in each advertising medium, the 'effectiveness' attained through sales promotion, the 'effectiveness' attained through pricing, and the 'effectiveness' attained through product developments are added for each team.

Market shares are then allocated in direct proportion to each team's total attained effectiveness.

The task of computing (from the total market and market share figures)

company sales (units)

company sales ($)

may be performed either by the teams or by the referees, according to the manpower available.

The computation of Total Cost, consisting of:

Manufacturing cost
Advertising
Sales Promotion
New Product Development
Distribution
Information Purchase.

as well as the computation of profits, is performed by the teams.

LAUSANNE MARKETING GAME

PLAYER'S INSTRUCTIONS

1. General

Your firm is a producer of semi-durable consumer goods, competing in a market with a number of other manufacturers marketing their brands of the same product.

2. Competitive Tools

Your competitive marketing weapons are the following:

Advertising: Each period, you must decide how much money will be allocated to advertising. Total advertising outlay is broken down into expenditures on:

Newspapers
Magazines
Radio and T.V.

The allocation of funds to these three media is a decision to be made by the firm.

Pricing: Each period, you must fix your selling price to the retailer.

Sales Promotion: Each period, you must decide how

much is to be spent on sales promotion.

Product Development: Each period, you must decide how much money is to be spent on the development of new products (which includes such elements as packaging, product styling, etc.) The effects of these expenditures may not be immediately felt.

3. Production Costs

Production costs are generally constant at $100/unit but may be higher at extremely low production quantities.

4. Production

There is sufficient capacity to product all units sold within the period sold. Thus, there are no beginning or ending inventories.

5. Distribution Costs

You are presently distributing through a wholesaler who takes a commission of 15% of the price charged to the retailers.

6. Additional Information Available.

At certain points in the game, you will be offered additional information at predetermined prices.

7. Decision Periods

You will be required to make your decisions approximately every fifteen minutes, corresponding to a business quarter.

8. Cash on Hand

$20,000 all of which may be spent on marketing. (Production costs may be defrayed until after sales have been made).

DECISION FORM - THE LAUSANNE MARKETING GAME

PERIOD _____

TEAM _____

TOTAL INDUSTRY SALES [ ] x % MKT SHARE [ ] = No UNITS [ ] x UNIT SALES PRICE [ ] = GROSS SALES [ ]

UNITS SOLD [ ] x UNITS PROD. SOLD [ ] = TOTAL PROD. COST [ ]

* ADVERTISING [ ]

NEWSPAPERS [ ]

MAGAZINES [ ]

\+ RADIO+T.V [ ]

\+ [ ] = TOTAL ADVERT [ ]

* SALES PROMOTION [ ] = SALES PROMOT [ ]

* PRODUCT DEVELOPMENT [ ] = PROD. DEV' [ ]

DISTRIBUTION [ ] = DIST. COST [ ]

INFORMATION [ ]

TOTAL MARKETING COST [ ]

\+ [ ]

TOTAL COST [ ]

PROFIT/LOSS [ ]

* MINIMUM INCREMENT £1,000

LAUSANNE MARKETING GAME

UMPIRES FORM

TEAM _____

ADVERTISING

PERIOD	0	1	2	3	4	5	6	7	8	9	10
CARRY OVER											
NEWSPAPERS											
MAGAZINES											
RADIO+T.V											
PERIOD TOTAL											
E_A											

SALES PROMOTION

PERIOD	0	1	2	3	4	5	6	7	8	9	10
E_{SP}											

HIGH CURVE ☐

LOW CURVE ☐

PRODUCT DEVELOPMENT

CUMULATIVE EXPENDITURES	0	1	2	3	4	5	6	7	8	9	10
E_{PD}											

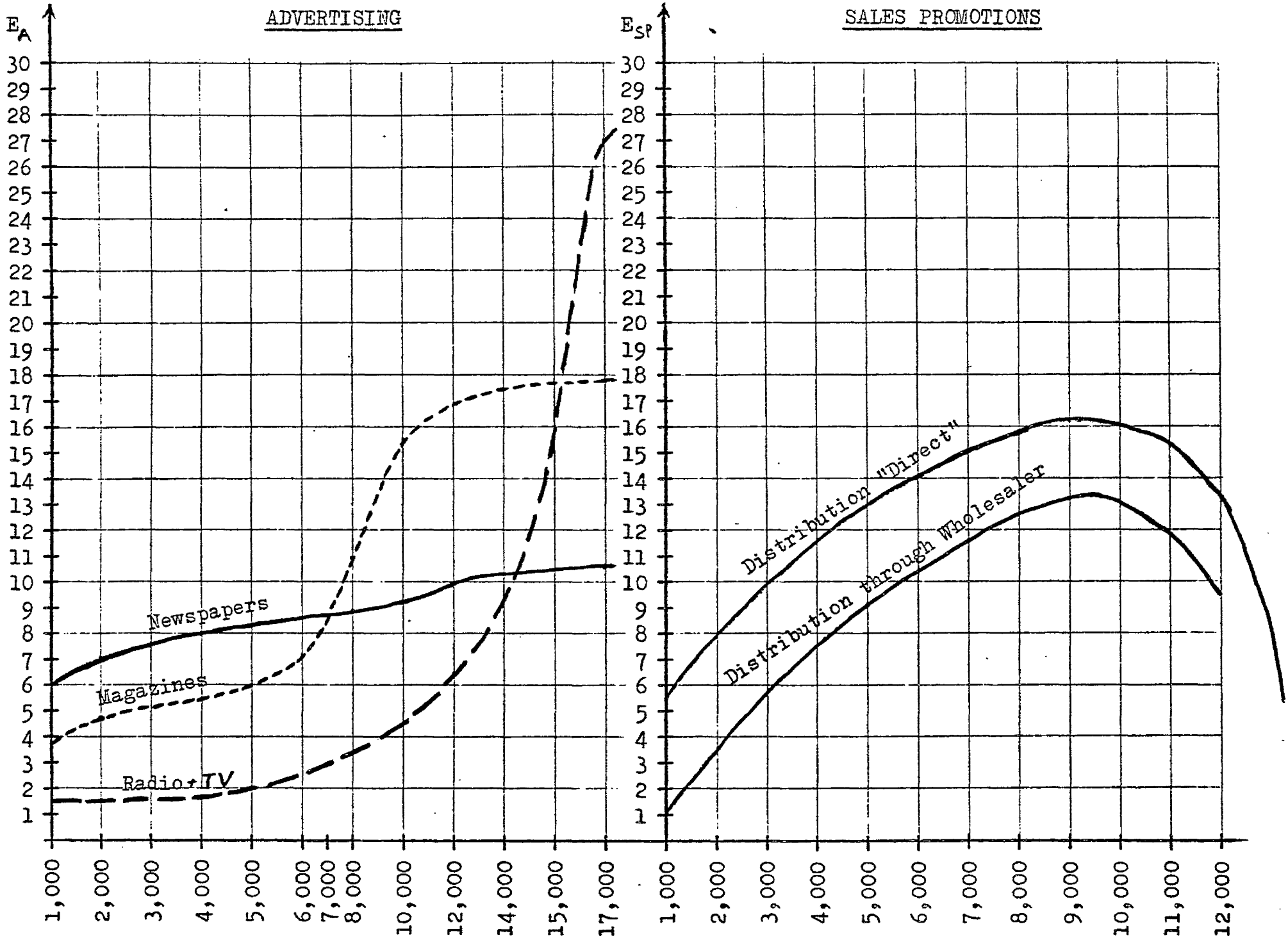
NOTE: AMORTIZE EFFICIENCY BY ½ EACH PERIOD

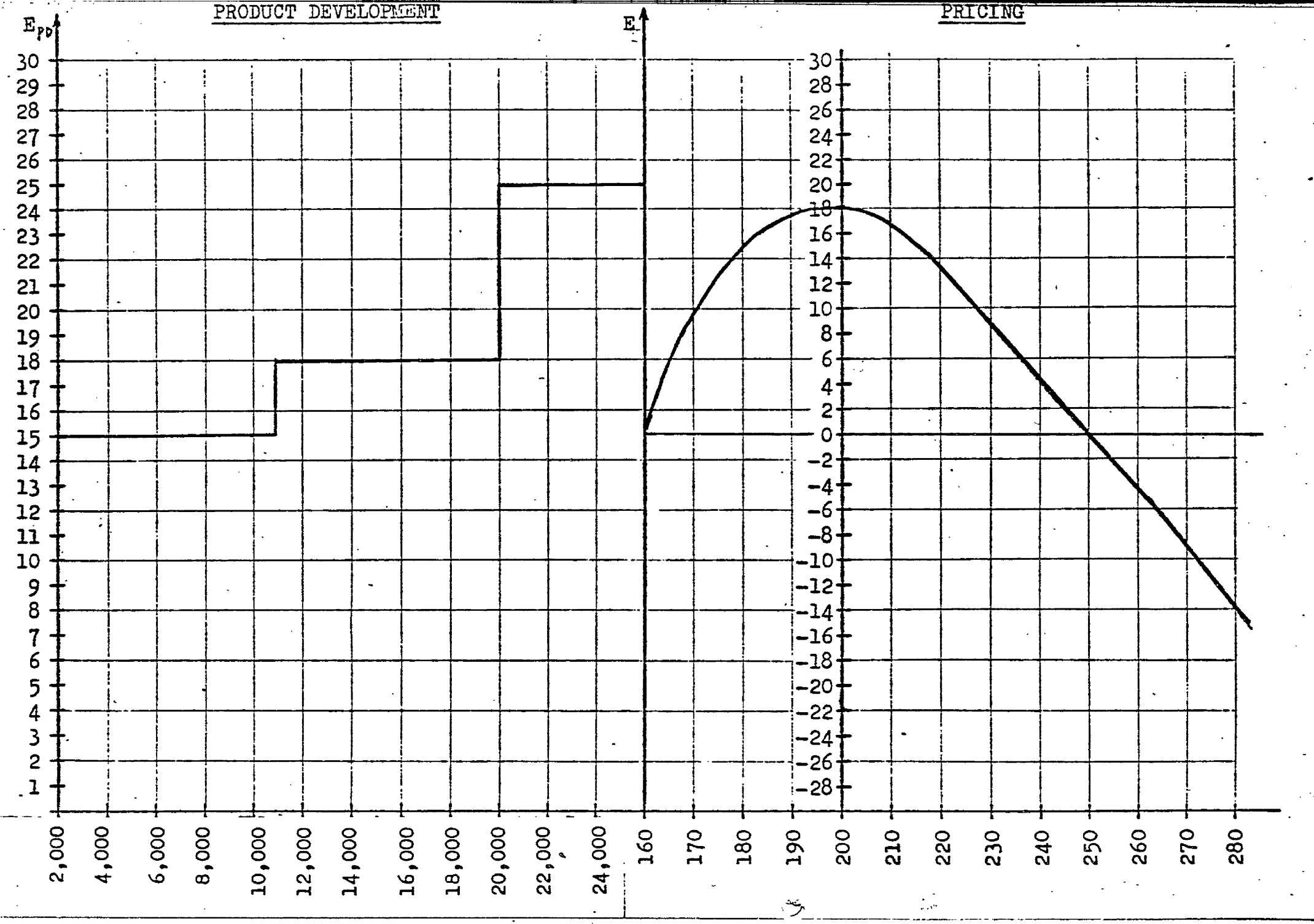
SELLING

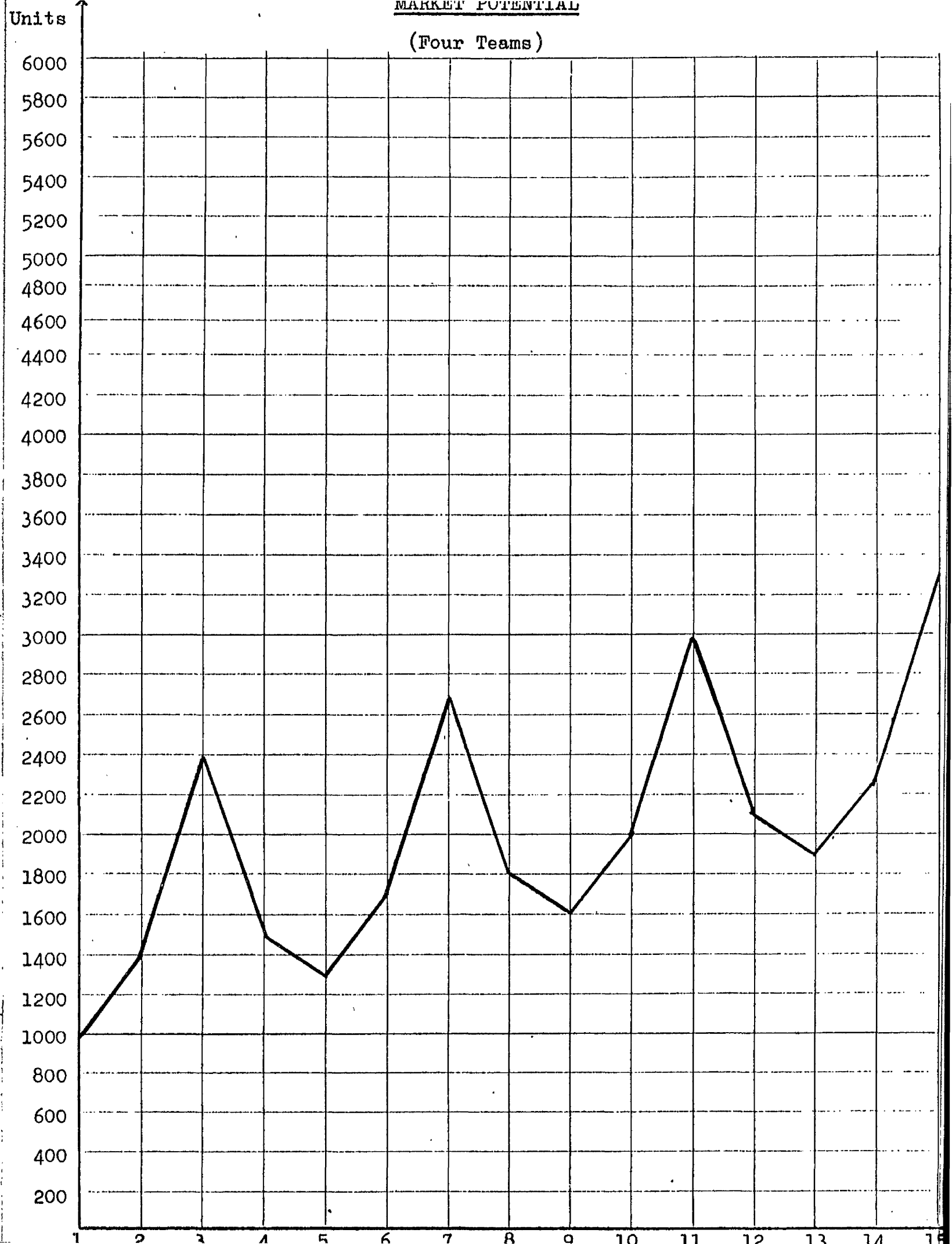
	0	1	2	3	4	5	6	7	8	9	10
E_S											

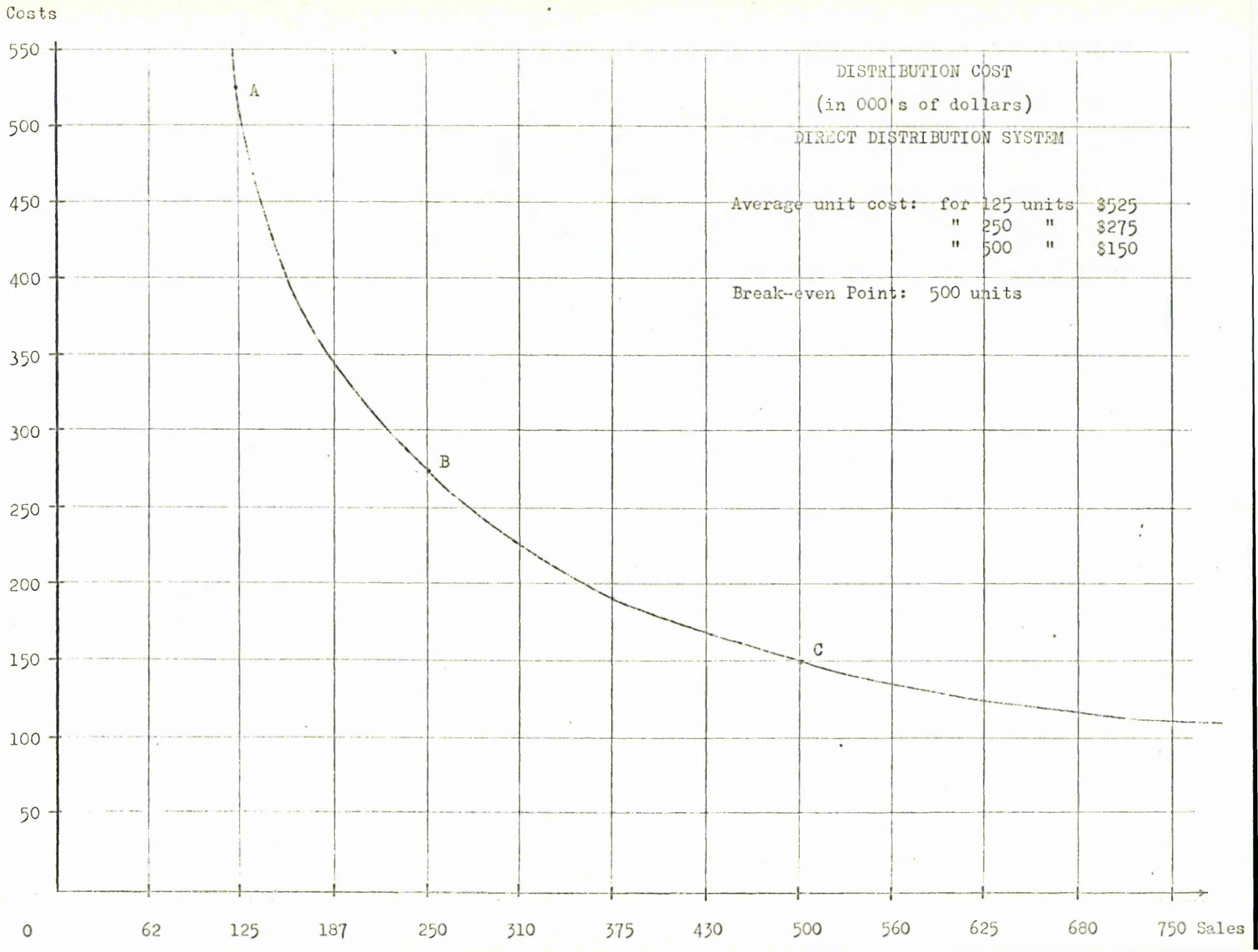
ΣE:

	0	1	2	3	4	5	6	7	8	9	10
E_A											
E_{SP}											
E_{PD}											
E_{PRICE}											
ΣE											


ADVERTISING
E_A
SALES PROMOTIONS
E_{SP}
Newspapers
Magazines
Radio+TV
Distribution "Direct"
Distribution through Wholesaler


PRODUCT DEVELOPMENT
E_{PD}
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
E
PRICING
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
160
170
180
190
200
210
220
230
240
250
260
270
280


MARKET POTENTIAL
(Four Teams)
Units
6000
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
1
2
3
4
5
6
7
8
9
10
11
12
13
14


Costs
550
500
450
400
350
300
250
200
150
100
50
0
62
125
187
250
310
375
430
500
560
625
680
750 Sales
A
B
C
DISTRIBUTION COST
(in 000's of dollars)
DIRECT DISTRIBUTION SYSTEM
Average unit cost: for 125 units $525
" 250 " $275
" 500 " $150
Break-even Point: 500 units

C H A P T E R 7

DIGITAL COMPUTER OPERATED GAME

This chapter is the English Electric Production Management Simulation. I wrote the model for this game, which is based on the battery production of Oldham & Sons Limited, Denton. After completing the model and structure of the exercise, the Operations Research Group at English Electric, Kidsgrove, under the direction of David Robinson, programmed and debugged the game. I then used the game for five weeks with 24 English Electric Middle Managers who participated in my executive development training programme there, which was the basis for the test questionnaire used in this thesis.

I have included sufficient information about the game to indicate its size and scope. The game is programmed on the English Electric Deuce Computer and this programme would be made available to any reader if so desired.

ENGLISH ELECTRIC PRODUCTION MANAGEMENT SIMULATION

SECOND VERSION

BRIEFING

You are the senior executive of a large concern manufacturing four kinds of battery (types A, B, C, and D) from the same three raw materials (cases, lead plates, and lead oxide paste). Your factory is in Birmingham, and you have warehouses in London, Bristol and Manchester for distributing your products in the South, West and North regions.

You will find that your main problem is one of keeping a balance between the conflicting requirements of economy in purchasing, in production, in distribution, and in stockholding. You, as a player, meet at simulated monthly intervals to decide what quantities of materials to order, what quantity of each type of battery to manufacture, whether to move stock to the regional warehouses, whether to engage or dismiss labour, etc. during the coming month.

Information of three kinds is available to guide your deliberations. First, there is permanent information contained in this document, which gives general background and incorporates the findings of some staff enquiries which have been carried out. Secondly, you will receive month by month an account of your achieved production, sales, and costs in the previous month. You can record or analyse these in any way you please, and you should be able after a time to assess the effectiveness of the decisions you have made. Lastly, certain consultants' reports about various functional aspects of the simulation will be available for sale as required by the run of the game. These will deal mainly with sales, as explained in detail later in this schedule.

Your first task will be to set up a formal organisation structure so that each member of the team, other than the director, has a specific functional area upon which to direct his attention. You must then decide upon the objective(s) towards which your team will direct its efforts. The most common policy will be the maximization of net profits. However, in

conjunction with this, you should consider such ancillary objectives as the maximization of the value of the firm as a going concern, (which is the way the firm will be viewed during the debriefing), the maximization of sales, the minimization of costs, etc. The team will then have to decide upon the strategies with which it hopes to reach its objectives, the controls it will use to judge its progress, and the means (budgets and graphs) by which it will record these controls.

There will be several other companies faced with the same problems. Although they may approach the problems quite differently, and their decisions will not in any way affect your decisions, you will still be competing with them. Each period the net profits of each team will be divulged to its competitors, and from time to time other information on the teams' performances will also be shared. These will provide you with a means of appraising the effectiveness of your decisions. You are required to keep some brief record of your policy and intentions at each stage, from which you could later construct a statement of how you operated

your company, and what considerations seemed most important at your meetings for use at the final critique.

Products

Type A batteries have recently been sold at £50 each. The demand is very seasonal, and expected to exceed 100,000 per annum. Orders have to be satisfied from the nearest regional warehouse (not from the factory) and if stocks are not sufficient the order is cancelled and the sale is lost.

Type B batteries have been sold at £225 each. Demand varies from month to month, but does not appear to be seasonal. About 30,000 are sold annually all through the regional warehouses. If stocks are inadequate any order which cannot be met is halved and deferred for one month.

Type C batteries have been sold at £450 each. Orders are fairly steady at about 1,000 per month, all being met from the regional warehouses. Orders which cannot be met are halved and deferred for one month.

Type D batteries are not stocked at the regional warehouses, but supplied direct from the factory on a delivery of up to 2 months. Manufacture takes one month, so it is possible to satisfy orders without holding any stock by authorising production of each order at the first monthly meeting after its receipt. You can, however, hold stocks at the factory if you choose to do so. Type D batteries are sold at £500 annual demand being between 10,000 and 15,000. Orders which cannot be met are halved and deferred for one month.

Sequence of Operations

Raw materials are available on one month's delivery; manufacture of batteries takes one month provided that materials and capacity are available; if not, the excess batteries scheduled are not produced. Transport to the warehouses is available in any quantity.

This means that if a monthly meeting decided to authorise the purchase of materials, the next monthly meeting could schedule production using those materials, and the third monthly meeting could decide to transport the finished products to any of the warehouses (where they will be available for sale as soon as the decision

has been taken). In the case of type D Batteries, the third monthly meeting would merely observe their presence in the factory warehouse ready for delivery to the customer within one month.

Raw Materials.

Battery cases, plates, and drums of lead oxide paste are normally available on one month's delivery in any quantities. Special prices for bulk purchases are given below, but large purchases tend to increase your stockholding costs (see next section).

	Small lots	20,000 or more	40,000 or more
Cases	£10. each	£9.18.0. each	£9.15.0. each
	Small lots	75,000 or more	150,000 or more
Drums of Paste	£4.0.0.each	£3.18.0. each	£3.16.0. each
	Small lots	100,000 or more	300,000 or more
Plates	£1. each	19s. each	18s. each.

The raw materials used in the manufacture of one battery are given over for the four different types.

Type of Battery	Cases	Drums of Paste	Plates
A	1	1	1
B	1	8	10
C	1	8	20
D	0	20	30

Holding Stock

At the time of each monthly meeting you will be told the total value of your stocks. These will comprise raw materials, work in progress and finished goods, at the factory, as well as types A, B, and C batteries at the regional warehouses. Generally there will be identical items of stock which have been obtained at different costs because the materials were purchased in different quantities, or because some production was carried out on overtime or for other reasons. This accounted for as the total value of each type of stock is divided by the number of items to produce an average unit cost.

During each month the value of your stock will change because of the intake of any materials you may

have ordered, because batteries have been produced, and because of sales. Materials are considered to arrive on the last day of the month, but production and sales proceed uniformly during the month. On this basis your average stockholding during the month is calculated.

The charge you pay for stockholding in any month depends upon your average holding during that month. If this amounts to £X million, you will be charged (X minus one)% per month up to a maximum rate of $3\frac{1}{2}$% per month if your stock reaches or exceeds £$4\frac{1}{2}$ million. This charge covers the maintenance and heating of your stores, materials handling, etc., as well as the financing of stock, all of which become more expensive as stocks rise, and are in any case high for the type of goods you handle.

Sales

Selling prices have been constant recently, and your expenditure on marketing (i.e. advertising and sales effort) has remained fairly steady. You are now at liberty to change your prices on types A, B, and C or your marketing expense if you choose, and this

will affect your sales. An increase in marketing expense will increase sales of these products and vice versa. Price changes will affect the sales only of the type(s) whose price is changed. Prices cannot be changed by more than 10% in any month. The marketing expense for the past few periods has been £200,000.

A sales forecast is available. This is based on the assumption that you will not change your price or marketing expenditure; if you do make changes, you should expect sales to be affected.

Distribution

Type D batteries cost £3 each to deliver to the customer, such delivery being made direct from the factory warehouse.

Types A, B, and C are distributed from the factory to the regional warehouses according to your decisions at monthly meetings. Batteries cannot be moved from one region to another or returned to the factory. Movement of batteries to a warehouse costs £3 per battery whichever region is involved.

Transport from the regional warehouses to the customer is included in the £3 charge.

Manpower and Productivity

The factory employs one class of direct labour. At present there are 4,000 trained workers on the payroll, drawing (on average) £80 per month. A trained worker produces each month either:

	8	Batteries	of	type	A
or	2	"	"	"	B
or	0.8	"	"	"	C
or	0.8	"	"	"	D

You can increase output by authorising overtime up to a maximum of 50% of normal working hours. Output will rise in proportion to hours worked, but overtime is paid for at $1\frac{1}{2}$ times normal rate.

Alternatively (or additionally) you can affect the productivity of the labour force by altering wages or changing the rate of expenditure on Plant administration, Welfare, Engineering and Maintenance, or Quality Control as detailed over page. You can change the size of the labour force if you wish. You can arrange to engage up to 500 extra workers in any month, the

output of a worker in his first month being only 70% of that in subsequent months. There is a cost of £40 (personnel expenses) for engaging a worker. You can dismiss up to 20% of the labour force at any time without notice, but this entails a cost of £80 per man dismissed.

Some of your workers will resign at the end of each month, but you can keep this to a minimum by spending more per worker on Welfare. If you reduce your Welfare expenditure the rate of attrition will rise, the response to such changes being spread over several months. It has been found that if £10 per worker is consistently spent on Welfare each month, the rate of attrition is 3% per month (e.g. if you have 4,000 workers and spend £40,000 per month you should expect to lose 120 workers at the end of each month).

Some output is lost in changeover and setup if you decide to schedule several types of battery for production in one month. Scheduling all four types for production in one month would entail three changeovers within the month, and so only 85% of your potential output

for that month would be realised.

Other factors affecting the productivity of your labour force are:

1. Wages You can increase wages if you choose, and this will have a permanent beneficial effect on output. You cannot ever decrease wages.

2. Plant Administration. You can vary your expenditure on plant administration, and this will have an effect on productivity since it represents the provision of services to assist production personnel. The effect in each month depends solely on the expenditure for that month. Fairly large changes are needed to produce significant effects. If you vary your labour force, you should vary the plant administration expense similarly, to maintain a constant expenditure per worker.

3. Welfare This expense covers items such as subsidies to the social clubs and canteen, transport for workers from outlying districts, etc. all of which can be curtailed or increased without notice. The expenses should be related to the number of workers employed, and

the effect on productivity in any month depends on the expenditure during several previous months. Welfare expenses also affects labour turnover, as described above.

4. Methods Engineering This expenditure covers work study and the development of improved methods of production. Expenditure per unit of output affects productivity for several months after the outlay is made.

5. Maintenance The effects of a change in maintenance expense per unit of output will appear gradually over several successive months.

6. Quality Control Expenditure under this head affects the proportion of your product which will be scrapped at final inspection for a period of several months ahead, and so affects the unit cost of good output.

Consultants' Reports

As mentioned previously, the volume of orders you receive depends upon the amount you spend on marketing and (for types A, B, and C) upon your selling prices. A firm of consultants has carried out an investigation

by varying marketing expense and price of similar products in selected localities in order to form an estimate of the effectiveness of such changes. You are able to purchase this information from them if you wish by buying any of the following four reports. The price of each is £100,000.

Report No. 1 states the approximate percentage change in volume of orders for type A batteries which can be expected if you increase marketing expense to £240,000 or reduce it to £160,000 per month.

Report No. 2 states the approximate percentage change in volume of orders for type A batteries which can be expected if you increase or decrease prices by 10% from the opening price (£50).

Reports No's. 3 & 4 give corresponding information for types B and C. The price of type D batteries is fixed.

At a later stage you will be offered the opportunity to purchase consultants' reports relating to productivity also at a price of £100,000. Report No. 5 gives an estimate of the change in productivity which could be expected to result from a 20% increase or decrease in

plant administration expenditure. Report No. 6 gives a similar estimate with respect to changes in maintenance expenditure.

In November of each year you will be able to purchase a sales forecast for the following year. Three forecasts of different estimated accuracies will be available at different prices. Details will be available nearer the time.

SALES STAFF REPORT

Sales forecasts have been made for the four types of battery, and are given below, but you should remember that they are based on the assumption that you will not change your prices or your marketing expense.

In the past, sales have been divided between the regions with 60% in the South, 30% in the West and 10% in the North. Stiffer competition is expected to reduce sales in the South of Type B and C, but there is an expanding market in the North for all products.

The forecasts are as follows:

Type A	South	West	North	Total
January	4,800	2,400	800	8,000
February	3,600	1,800	600	6,000
March	4,200	2,100	700	7,000
April	5,300	2,700	1,000	9,000
May	6,400	3,300	1,300	11,000
June	7,000	3,600	1,400	12,000
July	7,400	3,900	1,700	13,000
August	6,800	3,600	1,600	12,000
September	6,200	3,300	1,500	11,000
October	6,200	3,300	1,500	11,000
November	5,500	3,000	1,500	10,000
December	5,500	3,000	1,500	10,000

Assuming that you do not change your price and marketing expense, the above forecasts of total scales for each month are expected to be correct to between 10% and 15%.

Type B

Orders for Type B are expected to average about 2,500 per month, divided about 1,500 in South, 750 in West, and 250 in North. However, orders for Type B

fluctuate considerably from month to month, in no predictable pattern, and last year the low month was 1,931 and the high month was 3,234.

Type C

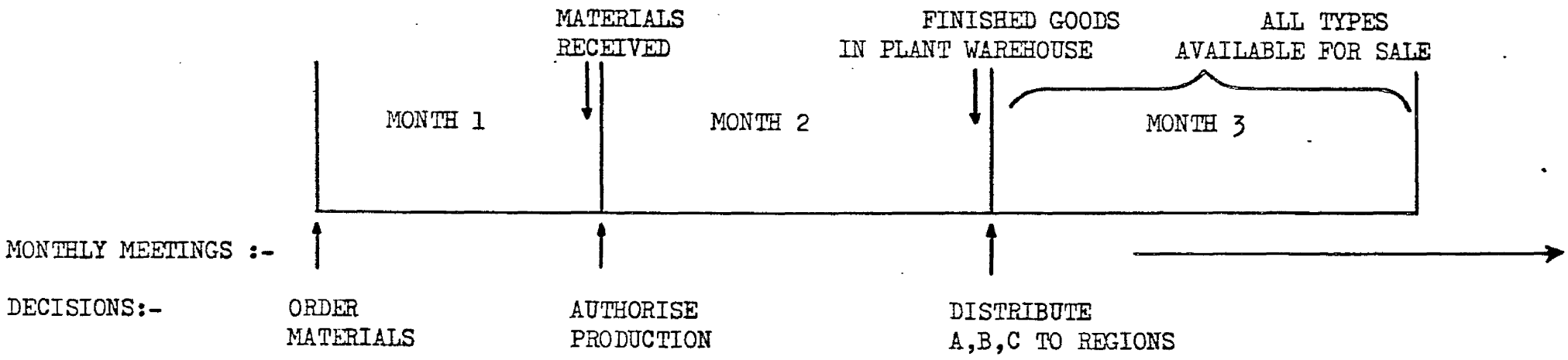
As in the past, orders for Type C are expected to hold quite steady at about 1,000 per month, with about 600 in the South, 300 in the West and 100 in the North.

Type D

Type D batteries are a job shop item; you have not normally produced them until an order has been received. It is expected that total orders this year will amount to between 10,000 and 15,000. However, it is not possible to predict in advance when an order may be received.

SEQUENCE OF OPERATIONS

ENGLISH ELECTRIC PRODUCTION MANAGEMENT SIMULATION



ENGLISH ELECTRIC PRODUCTION MANAGEMENT SIMULATION

DECISION FORM

MONTH

YEAR

COMPANY NO.

RAW MATERIAL ORDER

CASES

DRUMS OF PASTE

PLATES

PRODUCTION AUTHORISED

BATTERY TYPE A

" " B

" " C

" " D

DISTRIBUTION TO WAREHOUSES

REGION	TYPE
SOUTH	A
"	B
"	C
WEST	A
"	B
"	C
NORTH	A
"	B
"	C

LABOUR RESOURCES

NUMBER TO BE ENGAGED

NUMBER TO BE DISMISSED

OVERTIME REQUIRED
(PUT 1, IF YES,
0, IF NO.)

WAGE INCREASE
£/MONTH

PLANT EXPENSES

PLANT ADMINISTRATION

WELFARE

ENGINEERING

MAINTENANCE

QUALITY CONTROL

PRICE DETAILS

BATTERY TYPE D 5 0 0

" " A

" " B

" " C

EXCEPTIONAL EXPENSE

MARKETING EXPENSE

COMPUTER OUTPUT 1

ENGLISH ELECTRIC PRODUCTION MANAGEMENT SIMULATION MODEL 2

OPERATING STATEMENT — MONTH 12 — YEAR — COMPANY 1

	D	INCOME	COST	MARGIN	PRICE D 500
SOUTH	A	300000	199317	100683	A 50
	B	337500	199500	138000	B 225
	C	270000	165600	104400	C 450
WEST	A	150000	99257	50743	
	B	168750	99750	69000	
	C	135000	82800	52200	
NORTH	A	50000	33158	16842	
	B	56250	33250	23000	
	C	45000	27600	17400	
			GROSS MARGIN	572268	

CORPORATE OVERHEAD	200000
MARKETING EXPENSE	200000
DISTRIBUTION EXPENSE	16500
STOCK HOLDING EXPENSE	52489
PERSONNEL EXPENSE	
EXCEPTIONAL EXPENSE	
TOTAL EXPENSES	466989

NET PROFIT 103279

TOTAL NET PROFIT TO DATE 2000000

SALES INFORMATION

	D	NEW ORDS	OK ORDR	SALES	DEFER	CANCEL
SOUTH	A	6000		6000		
	B	1500		1500		
	C	600		600		
WEST	A	3000		3000		
	B	750		750		
	C	300		300		
NORTH	A	1000		1000		
	B	250		250		
	C	100		100		
TOTAL	A	10000		10000		
	B	2500		2500		
	C	1000		1000		

COMPUTER OUTPUT 2

PLANT REPORT

PLANT EXPENSES	
PLANT ADMINISTRATION	160000
WELFARE	40000
METHODS ENGINEERING	60000
MAINTENANCE	24000
QUALITY CONTROL	24000
DIRECT LABOUR WAGES	320000
OVERTIME	
TOTAL PLANT EXPENSES	628000

LABOUR REPORT

FINAL NUMBER OF WORKERS	3880
NUMBER ENGAGED	
NUMBER DISMISSED	
NUMBER RESIGNED	120
AVERAGE MONTHLY WAGE	80

	A	B	C	D
PLANT CAPACITY ONE PRODUCT	32000	8000	3200	3200
PRODUCTION LEVEL SET	20000	1000	2000	
PRODUCTION ACHIEVED	13091	655	1309	
MATERIAL COST	191129	32750	90059	
PLANT EXPENSES	285446	57129	285425	
TOTAL EXPENSES PER PRODUCT	476575	89879	375484	
UNIT COST	36.40	13722	286.85	

STOCK REPORT

RAW MATERIALS	INITIAL	IN PROD	RECEIVED	FINAL	U.COST
CASES	45000	16364	20000	48636	984
DRUMS OF PASTE	85000	28803	75000	131197	390
PLATES	100000	45821	70000	124179	90

PLANT STOCKS		INITIAL	SHIPPED	PRODUCED	FINAL	U.COST
	A	3000	3000	13091	13091	3640
	B	2000	1500	655	1155	13539
	C	1000	1000	1309	1309	28685
	D					

REGIONAL STOCKS		INITIAL	RECEIVED	SALES	FINAL	U.COST
SOUTH	A	8000	2250	6000	4250	3322
	B	2000	500	1500	1000	13300
	C	800	334	600	534	27600
WEST	A	4000	375	3000	1375	3309
	B	750	500	750	500	13300
	C	400	333	300	433	27600
NORTH	A	2000	375	1000	1375	3346
	B	150	500	250	400	13300
	C	300	333	100	533	27600

TOTAL FINAL STOCK VALUE 3009468

C H A P T E R 8

THE VALIDITY OF GAMES AS A TEACHING TOOL

VALIDATION DONE IN THE PAST

In their article on "The Development of Dynamic Business Exercises in North America", Peter Kirkham and Andrew Grindlay[13] in 1965 state:

> "It now appears unlikely there will be any proof of the effectiveness of business exercises in the near future. Should they therefore be included in a business curriculum?"

In fact some small studies of game validity had already, by that time, been undertaken. Bertil Hallsten of the Stockholm School of Economics undertook a study in 1962, the results of which were privately circulated. He asked educators who had competed in or used business games to evaluate their usefulness in a management teaching programme. The eight techniques for comparison were:

---

13. P. Kirkham and A. Grindlay "The Development of Dynamic Business Exercises in North America". Assoc. of Teachers of Management, Occasional Papers No. 1. Oxford. February, 1965.

a. Study of literature.

b. Lectures.

c. Problem solving.

d. Case studies, preparation and discussion.

e. Writing and presenting minor research papers.

f. Functional business games.

g. Small general business games.

h. Large general business games.

He asked them to budget these in relation to their usefulness:

1. To convey knowledge of facts.

2. To convey knowledge of methods in managerial economic analysis.

3. To convey knowledge of statistical methods for collecting and analysing data.

4. To improve decision making ability.

5. To train the ability to work independently.

6. To work in co-operation with others.

His conclusions state:

> "Regarded as a whole, the material collected seems to support the opinion that nowadays

business game should be included among other educational tools as a natural and important method of instruction. The very large time allocation, that in many cases has been given to the various forms of games must, in all probability, be viewed with some reservation. One important factor is that the individuals who completed the questionnaire had just participated in a game. Thus, their attitude in general was probably quite positive. Also, the specification of no less than three types of business games might have created an overemphasis on games. Even with considerable conservatism in the interpretation of the results, one is entitled to conclude that our brief investigation demonstrates how business games, as a tool for education, must be considered enriching for educational programmes in business economics and management."

In 1962 McKenney reported on exercises with business games in a course on production management for first year M.B.A. students at the Harvard Business School.[14] Students were divided into two groups; one group took part in a business game and the other participated in case studies. McKenney found that the business game decidedly affected the achievements of his students. He claims, as a subjective view, that they received a better understanding of the various functional decisions of a company. 65% of the students claim that the time on exercises was well spent, 30% thought that the exercises could have been shorter, and 5% felt that it was a waste of time. In 1963 McKenney did another experiment comparing time spent on a "complex general management game" to equivalent time spent on "cases" in learning about:

1. the effect of previous decisions on present opportunities.
2. the role of sequential planning in goal attainment.
3. the interdependence of functions within a firm.

The experimental group devoted 4 class periods for ten weeks to the game. All students did a written case

---

14. J.L.McKenney. "An Evaluation of a Business Game in an M.B.A. Cariculum" Journal of Business No.3. 1962.

analysis before and after the experiment. McKenney, with reservations, stated:

> "the results seem to support a trade of case time for game time if planning, as defined by concepts 2 and 3, is one of the teaching objectives of the course. There was no discernable difference of students awareness of concept No. 1."

This impressionistic type evaluation has also been done with practising managers. In studies undertaken by the Pilsbury Company relating to their Pilsbury Sales Game and by the General Electric Company (U.S.A.) relating to their Marketing Strategy Simulation exercises, they both reported the games as "highly effective".[15] The impressionistic survey which I found most interesting was undertaken by Delbert C. Hastings Director of Research, Department of Business Administration, University of Minnesota. This immediately followed the participation of a group of business men in the Univac Market Management Simulation in May 1960.

---

15. P.S.Greenlaw, L.W. Herron, R.H. Rawdon. "Business Simulation in Industrial and University Education". Prentice Hall, New York. 1962. P.50.

A copy of this study was made available to me by the Univac Division of the Sperry Rand Corporation. The results of this questionnaire were highly favourable and helped me in some ways in structuring my own experiment. I will quote below some of Dr. Hastings conclusions:

> "There appeared to be little differentiation in feeling of value of the game according to the position level of respondents.
>
> "By and large this group judged the game they played to have certain lasting values, in giving a feeling for the overall operation of a business and for the use of computers in business. (the lasting value was being judged one week after participation)
>
> "Respondents attitudes towards the value of the game were found to have little, if any relationship, to the relative success (profitability) of their team." (I will disagree with this statement later in this ~~paper~~ thesis)

Unfortunately the group was only 57 respondents and no attempt at statistical analysis was made of the data.

Although most work which has been undertaken has been of the impressionistic nature, an experimental approach was recently tried by John Fairhead of the College of Advanced Technology, Birmingham.[16] Here he tested a group of students playing a business game and a control group which attended a lecture set with a battery of three "before and after" tests.

Test 1 - A twenty item attitude survey devised by Elliott (1958) on the Functioning of Committees and decision making groups.

Test 2 - 31 Statements of fact or opinion about aspects of executive management that are simulated in the game to be judged true or false.

Test 3 - A group task which had been standardised by Will Howell and John Fraser. The experimental group was 24, In his results he states:

> "The statistical results were disappointingly insignificant, but so have been the results of

---

16. J. Fairhead. "The Validation of Business Exercises". ATM Bulletin No. 19. September, 1965. Birmingham.

other experimental learning in management courses.

"One possible cause of the inconclusiveness of the experiment may be that the population was too small.

"The pilot experiment in learning suggests that in order to measure differential learning effect on simulations we may require more test items, pre-tested to discriminate better."

MY APPROACH

In the light of the foregoing, in setting out my validity experiment for the purpose of this thesis, I decided to rely basically on the technique of attitude questionnaires which had been developed in the Management Science Department of the Manchester Institute of Science and Technology under the leadership of Professor Revans. This technique had shown that it allowed the publication of statistical valid results, if such results were inherent in the experiment organised. I decided to use the impressionistic type

of test which the attitude questionnaires required for the reasons stated above. My steps in the experiment were as follows:

1. Find a series of statements to test.
2. Test the reply statements as to statistical utility.
3. Eliminate those statements which do not have significant scatter in results and include further statements indicated by analysis.
4. Develop a game which is reliable and solicits a positive response from participants.
5. Find an experimental group which is so "wide based" so as to ensure:
    a. no collusion in response.
    b. statistical significance of results.
6. Play the game with members of this group(s) over approximately one year.
7. Wait three months and administer the test to the entire group.
8. Analyse results.

1. Find a series of statements to test - After playing the English Electric Production Management Simulation with 24 members of the Middle Management of the Computer

and Control Gear Divisions of English Electric for 5 weeks, I administered the questionnaire below to the participants, their subordinates and their superiors. The questionnaire asked for the recall of attitudes towards or about the game expressed by the participants in the presence of the respondent. I also interviewed a selected sample. The questionnaire was administered to approximately 300 individuals with about a 70% response. It asked the following six questions with the following notes about each:

a. the frequency of comments of all kinds (since the exercise finished have you heard, on average, one comment a day, or one a week, or one a month? Do some of them frequently recall their experience and others rarely, if ever? Do any of them show a tendency to go over their Simulation again with others who participated with them?)

b. the occasion on which, in your view, the most telling comment was passed. (Was this a social one, such as over lunch, or an official one, during the discussion of a working problem, or in some other circumstances?)

c. the main content of the comment or comments you have heard most frequently (Were these about the impression that the exercise had made upon whoever passed them? Were they about a work situation that showed some resemblance to a simulated situation? Were they about the type of argument or about the inadequate information that characterises the team decision made in such a Simulation? Or were they about some other matter?)

d. the attitude or expression of the individual passing the comment/s (Was this serious, light-hearted, ironical? Did it reveal any marked attitude towards our attempt to simulate industrial experience?)

e. the response of those who overheard the comment/s and a note of any discussion which it led to.

f. any further information about the comment/s that you think relevant for me in gauging the impact which the Simulation has made on those who took part.

The response rate to each question was calculated as to the number of words, number of comments and general attitude. I then categorised all comments made under

the following heading: emotional, hope, subjects of learning, critisism and appraisal.

2. Test the reply statements as to statistical utility - These were then randomly mixed into a 57 item questionnaire requiring the response; strongly agree, agree, undecided, disagree, or strongly disagree to each item. The randomness was introduced for the purpose of testing the internal validity of the questionnaire. In addition, the names of all the participants were included on the front cover of the questionnaire and the respondent was asked to ring the team number that the respondent's informant was in. These questionnaires were administered to the same group of 300 and the response rate was about 50%.

The same questionnaire was administered to two further groups. One was a group of about 20 top managers at U.S. Industries, Burtonwood. This Company had been known as the Burtonwood Engineering Company Limited. In 1961 it was taken over by U.S. Industries and a new board of directors superimposed on the

existing management structure. In an effort to weld this new structure into a cohesive team and to train the old managers to accept the new techniques being brought in by the American parent, a training programme of games only lasting four months was instigated, including all board members and their immediate subordinates.

The other group of 24 included all the directors and their subordinates from two divisions of the Lloyds Packaging Warehouse Group. Each of these divisions had recently had a "Company Doctor" installed as its Managing Director, and the group had similar needs and a similar programme to the U.S. Industries Company. At the end of the training period, the questionnaires were administered to both of these groups.

3. Eliminate those statements which do not have significant scatter in results and include further statements indicated by analysis - Upon examination it was found that several statements solicited an either all positive or all negative response and did not show any scatter of results. These were therefore eliminated because they did not discriminate

and they would not help in our final analysis. Comments were solicited at the bottom of each questionnaire and from these comments, a number of new statements were evolved which were included in the final questionnaire. As this test was only used to develop the final questionnaire, no serious statistical analysis was undertaken of these questionnaires, but several items did emerge. Those questionnaires filled in by participants seemed to be most valid and have the most answered statements. It was also impossible to differentiate between the teams in the English Electric experiment, as most respondents said that they knew players in at least three or sometimes four of the teams, which reduced the usefulness of this type of analysis entirely. Otherwise it might have been possible to test the effect of good performance in the simulation within these six groups.

4. Develop a game which is reliable and solicits a positive response from participants - By this time ATHENA existed and I had already used it for the complex "BRACE" game included previously. From my analysis of

the structure of that game I decided on the basic structure of an exercise which I would use for the test. This structure was completely generalised and did not relate to any industry or group. I tested that structure with post-graduate students at the University and with four industrial groups in the Manchester area. I found that the structure was highly competitive and involving and that it had internal validity, that is, it responded to team decisions to the satisfaction of the participants.

5. Find an experimental group which is so "wide based" so as to ensure, a. no collusion in response, b. statistical significance of results - The finding of groups to participate in the experiment presented some problem. I had set out to find approximately 300 individuals, which allowing for a reasonable response rate, would give me a statistically significant group. However, I wanted to ensure that the participants came from a wide enough geographical area and from different companies, so as to ensure no collusion in response. I felt the only possibility would be to appeal to a number

of industrial federations which have members dispersed over a wide area, which would allow me to find the group that I wanted. Two federations did come forward. The first was the British Federation of Master Printers who organised six, one day gaming conferences spread all over England, from Blackpool to London and Leeds to Bristol. The other was the Engineering Employers West of England Association. They arranged four conferences over a 14 month period which each lasted $2\frac{1}{2}$ days. Although the Engineers Conferences were all held at Chewton Place, Keynsham, Somerset, the managers came from all over England. A list of some of their geographical origins is included in the Appendix.

6. Play the game with members of this group(s) over approximately one year - Each group of printers had approximately 25-50 participants. They played a simplified version of the basic game called CAXTON'S game. The engineers were in groups of between 18 and 25. The game which they played was a more complex version of the basic game called WEST (Western Employers Simulation Training). These games and their selection are explained in Chapter 9.

7. Wait three months and administer the test to the entire group. - Three months after the last group had participated for the engineers, the finalised test was administered.

8. Analyse results - this analysis forms the basis of Chapters 10 and 11.

C H A P T E R 9

THE TEST

Two main groups participated in the test; the British Federation of Master Printers and the Engineering Employers West of England Association.

PRINTERS

The first game run for the Printers was at Reading University in April 1964. Of the 51 participants 28 responded to the questionnaire. The second game was run for the Lancashire and Cheshire Master Printers Alliance in Blackpool in October 1964. 26 of the 42 participants responded. The third was run in London for the London Master Printers Association in November, 1964. 15 of the 22 participants responded. The fourth game was run for the Home Counties Master Printers Alliance in London in January 1965. 18 of the 28 participants responded. The fifth game was run in Birmingham for the Midlands Master Printers Alliance in March 1965. 15 of the 22 participants responded. The last game was run for the East Anglian Alliance of Master Printers in April 1965 at Cambridge. 19 of the 22 participants responded.

The response pattern looks like this:

GROUP	1	2	3	4	5	6	TOTAL
Respondents	28	26	15	18	15	19	121
Participants	51	42	22	28	22	22	187
Average Response	54.9	61.9	68.1	64.2	68.1	68.3	64.7

The overall response rate was 64.7%. This was achieved with only a single mailing; there was no reminder. The progression in response rate ~~is clearly highly~~ suggests a significant improvement, but it is interesting to note that even after 17 months had elapsed (the questionnaires were sent in September, 1965) over 50% of the original group responded. It should be emphasised that although all the participants were members of the same federation, no participant attended twice and no two participants came from the same factory, although in several cases we had people working within the same group in different parts of the U.K.

The participants fell mainly into the 30 - 35 age group. However, probably 20% of the total were over this age. Because of the peculiar structure of the

printing industry, a great many of these people held senior positions. The printing industry is notoriously a close family industry - that is handed down from father to son. Therefore, a great many of the young men who attended held directorships in large family firms.

The co-ordination for all the printers games came from the Federation Training Officer. The actual organisation was done by the Secretary of the Alliance concerned.

All the printers sessions were basically the same. They took place over one calendar day. This allowed approximately one hour for briefing, 4 hours for game play, and 2 hours for debriefing. The game which is included below was not changed at all during the six separate runs of the exercise; each exercise seemed to have an equally high level of participation and response during the debriefing session. In no game did the 4 hours play allow any Company to be completely "financially embarrassed" or on the other hand, any Company to dominate the market.

ENGINEERS

The games run for the Engineering Employers West of

England Association were more complex and run on a different basis. They were run over three calendar days and were residential. The courses were held at Chewton Place, Keynsham, Somerset. This is the newly built residential training centre of the Imperial Tobacco Company Limited. The response rate was:

GROUP	1	2	3	4	TOTAL
Respondents	19	20	19	17	75
Participants	25	25	22	18	90
Average Response	76.0	80.0	86.3	94.4	83.3

This gave an overall response rate of 83.3%. This was achieved by a first mailing of the questionnaire and a second reminder mailing. The participants ranged over a wide age group 30 - 60 and included many prominent industrial figures, including managing directors and directors of large engineering groups. At least 20% of each group that participated was made up of people with a financial or accountancy bias in their training or in their job. The general form of the courses was as follows:

Day 1

17.00	-	18.30	Briefing
20.00	-	21.30	Trial runs of the game to get familiarity with the format and model of forms.

Day 2

9.30	-	12.30	Game play
14.00	-	16.00	Game play
16.00	-	17.00	Mid game debriefing
17.00	-	18.00	Game play
20.00	-	21.30	Game play

Day 3

9.30	-	12.00	Game play
12.00	-	13.00	Preparation of final report
14.00	-	16.30	Final debriefing

The game which was used within this context although based on the same structure as the Printers game was of necessity more complex. The game period also allowed much greater interaction between the teams and more conclusive game results to be achieved in terms of profitability, etc. All the games were not identical in the way in which they were run. In game one all participants started in the same financial and asset position, and the game had a normal outcome, whereby all teams did reasonably well, but some better than others.

The second game was started in the same way but ended quite differently. One team had done very much better than the other four; three teams had done poorly and one team had done very poorly. This seemed to cause a great anxiety on the part of those who had done poorly. They seemed frustrated and embarrassed to have done poorly in a management game which was dealing with the same ideas and concepts as their day-to-day job. Because of the obvious tension caused by this situation, it was decided in a conference following the game, between myself andthe Deputy Training Officer of the Association, to start the third group off where the second group had ended.

This would mean that one group would be very strong, three weak, with one very weak. It was felt that this would take the burden of showing a profitable performance at least partially off the shoulders of all the participants. They could attribute part of any difference in asset positions, at the end of the exercise, to the disproportionate start of the exercise. We felt that

this would keep all team morales high and focus the participants attention on learning rather than on gaming. The results shown in Chapters 10 and 11 clearly demonstrate the results of this change. The fourth game was run under exactly the same conditions as the third.

CAXTON'S GAME

The game used for the Printers exercise is called CAXTON'S Game. This seemed most appropriate as not only did he print the first book in the English Language, but the first book which he printed was on Chess, the rudimentary war game. The game concerns the manufacture of table glass-ware. The reason for this is two-fold. If the game had dealt with the Printing industry as such, participants would carry over their knowledge of their industry to the game and expect the game model to perform as they believed that section of the printing industry in which they are regularly involved performs. In a relatively simple simulation such as this, this would be clearly impossible. Second, and more important still, if the game had dealt with the

printing industry, the participants might be encouraged to take any specific lessons that they had learned from relationships in the game, and carry them back to their job. As Caxton's Game deals principally with the need for planning and is not intended to teach specific lessons (as might be learned from a game relating to stock control), it was felt necessary to use a different industrial example. It would, of course, be possible to have a game of this complexity which did teach specific examples, and similarly to have a stock control game which did not, but generally the reverse would be true. Table glass-ware, however, has many of the qualitative characteristics of the printing industry. The importance of quality and design and in particular, the more or less singular raw material that both industries require. The players' instructions, decision forms, operating statements are included below:

CAXTONS GAME

THE BRITISH FEDERATION OF MASTER PRINTERS MANAGEMENT SIMULATION EXERCISE

This simulation exercise emphasises the planning elements of management. While the simulation is intended to have the basic characteristics of the printing industry, the product produced is glass tableware. This is to prevent you, the participants, from trying to bring too much of your own printing experience into the game, or, far worse, to try to take specific lessons from the game and apply them in your job. The intention of the game is not to teach specific lessons but to dramatically highlight areas of planning in management.

Since all companies operate within the same set of conditions and are covered by the same environment, it is obvious that the best performance will derive from the 'best' decisions made. This exercise then is a severe test of the participants ability to understand, analyse and interpret the information available in the conditions prevailing and the situations developing throughout the exercise. This is precisely the same situation in which a manager finds himself in 'real life'; these are the functions he performs every day.

UNIT COST OF PRODUCTION

You will find that many elements in this simulation are vastly simplified as compared to the 'real life' environment in which you work. This is to allow you, as participants, to concentrate your attention on a few elements in the decision making process which we will consider as critical during the course of this exercise. These elements are indicated below:

1. Production Quantity

Your company has a factory which has a capacity of producing 1,000 units of table glass-ware per month. The plant can be run at capacity plus 25% to minus 50%. It will be most economical in terms of unit cost of production to run the plant exactly at capacity and the greater the deviation the greater the increase in unit cost of production.

2. Quality

It is difficult to define this decision clearly, but it refers to quality consciousness, time taken in production, the presentation of the product, etc. Last year the quality of the product was 60% (100% is perfect), but this can be raised or lowered. This will, of course, affect unit cost of production, but will also have a major effect upon the saleability of your product.

3. Plant Administration

These are the overheads of running your firm. The minimum expenditure is £2,000 per month but during the past year you have spent £2,500 per month. Raising this expenditure will lower the direct unit cost of production but will raise the overheads and therefore analysis is needed to determine the point of diminishing returns.

4. Maintenance

The Company is now spending £1,000 per month maintaining its plant. There is, however, no reason to assume that this is the optimum expenditure. Increase in maintenance expenditure will lower direct unit cost of production but may raise the total cost of production.

The raw materials, mainly sand, are widely available, and therefore to simplify book-keeping, raw materials will be delivered as needed and their cost included in the direct unit cost of production.

There will be a charge for holding stock equal to 10% per unit of stock on the first of each month.

The standard direct unit cost of production is £5 per unit. The decisions which you make can either raise or lower this standard cost, and this information will be given to you by the referee after each decision.

COMPANY SALES

These will be determined by four decisions:

1. Price

At the present time, your Company is charging £11 for the quality of product which it is selling. Price may be freely raised or lowered; however, higher prices will tend to lead to a lower market share, assuming constant quality.

2. Quality

The same as decision 2 above.

3. Sales Promotion

This is a single expense item which includes the hiring, training, and services of salesmen as well as advertising and other sales promotional activities.

4. A Design Section

This is a yes/no decision where you may pay £250 per month to have a Design Section. This will be a major policy design, for better design will slowly increase saleability, but a Design Section will be an immediate burden upon cash resources.

The referee will indicate the market share achieved by your Company after each set of decisions.

Other market research information will be made available from time to time, some of which will only be available for sale.

CAXTONS GAME

OPERATING STATEMENTS

Team _____ Period _____

COSTS	£	
Production	_____	
Plant Administration	_____	
Maintenance	_____	_____
Stock Holding	_____	
Sales Promotion	_____	
Design	_____	
Others	_____	
TOTAL	_____	

STOCK	Units.
Opening Stock	_____
Last Months Production	_____
Total	_____
Less Sales	_____
Closing Stock	_____

CASH STATEMENT	£	£
Opening Balance	_____	
Sales	_____	
TOTAL	_____	_____
Costs		_____
Closing Balance		_____
Net Change		_____

CAXTONS GAME

DECISION FORM

Team _____ Period _____

Production Quantity	_____ UNITS
Quality	_____ %
Plant Administration (£2,000 min.)	£ _____
Maintenance	£ _____
Price	£ _____
Sales Promotion	£ _____
Design Section (number of months)	_____

Unit Cost	£ _____
Market Share	_____ %

WEST

The game played by the Engineers is called WEST (Western Employers Simulation Training). Close examination shows that the basic structure of both games is the same, for example, the operating statement format, but in WEST there is a greater emphasis on the production element of the exercise, a point brought out in the player's instructions. This balancing of the importance of production and marketing within the exercise puts an even stronger responsibility on the teams to organise carefully and plan ahead. The product produced is WIDGET. This is again intended to prevent the participants from viewing the exercise in terms of their own specific experience. I include a copy of all the information given to participants in team "C" in game 3 or 4, which was, at that stage, the strongest team. I also include the information given to team "D" which was one of the weaker teams. As some stress is placed on the difference between group 2, where all teams started from an equal position and finished in this position, and groups 3 and 4, which started from these positions, I have decided to include both.

TEAM C.

SIMULATION TRAINING EXERCISE "WEST"

MDE.01.

This simulation exercise emphasises the planning elements of management. The simulation is intended to have the basic characteristics of the engineering industry. The product produced is a WIDGET. This is to prevent you, the participants, from trying to bring too much of your own experience into the game, or, far worse, to try to take specific lessons from the game and apply them in your job. The intention of the game is not to teach specific lessons but to dramatically highlight areas of planning in management.

Although each Company starts from a different finanical and trading position they all operate within the same set of conditions and are covered by the same environment, it is obvious that the best performance will derive from the 'best' decisions made. This exercise then is a severe test of the participants ability to understand, analyse and interpret the information available in the conditions prevailing and the situations developing throughout the exercise. This is precisely the same situation in which a manager finds himself in 'real life': these are the functions he performs every day.

You will find that many elements in this simulation are vastly simplified as compared to the 'real life' environment in which you work. This is to allow you, as participants, to concentrate your attention on a few elements in the decision making process which we will consider as critical during the course of this exercise. These elements are indicated below:-

Your company ~~has~~ owns a factory costing £30,000 (hire purchase charge £250/month) capable of holding 6 production lines. There are 6 production lines installed, each costing £12,000 (hire purchase charge £100/line/month) 1 line is wholly owned by the Company, 5 are on hire purchase. There is a ready market for scrap lines at £3,500 each outside your marketing area. If you wish to dispose of a line, therefore, you may sell to this outside interest through the umpire or you may negotiate it's sale to one of your competitors. The vendor will, however, still be liable for the remaining 5 years of the H.P. agreement (10 years have been paid) unless he transfers this liability. New lines are available from the umpire on 3 months notice. They cost £12,000 or £100/month for 15 years. Any H.P. agreement can be terminated by paying 90 per cent of the balance owing. Each production line is capable of producing 250 WIDGETS/month.

UNIT COST OF PRODUCTION.

1. Production Quantity.

Your company has a factory with a present capacity of producing 1500 WIDGETS per month. The plant can always be run at capacity plus 25% to minus 50%, It will be most economical in terms of unit cost of production to run the plant exactly at capacity and the greater the deviation the greater the increase in unit cost of production.

2. Quality.

It is difficult to define this decision clearly, but it refers to quality consciousness, time taken in production, the presentation of the product etc. Last year the quality of the product was 60% (100% is perfect) but this can be raised or lowered. This will, of course, affect unit cost of production but will also have a major affect upon the sale-ability of your product.

3. Plant Administration.

These are the overheads of running your firm. The minimum expenditure is £1,000 per month, but during the past year you have spent £2300 per month. Raising this expenditure will lower the direct unit costs of production but will raise the overheads and therefore analysis is needed to determine the point of diminishing returns.

4. Maintenance.

The Company is now spending £450 per month maintaining its plant. There is, however, no reason to assume that this is the optimum expenditure. Increase in maintenance expenditure will lower direct unit cost of production but may raise the total cost of production. This expenditure must be related to total capacity available and the use there-of.

The raw materials are widely available, and will be delivered as needed and their cost included in the direct unit cost of production. This and other rules are made to simplify bookkeeping.

There will be a charge for holding stock equal to 5% of the value of stock on the first of each month.

The standard direct unit cost of production is £4-7-1 per unit. The decisions which you make can either raise or lower this standard cost and this information will be given to you by the referee after each decision.

COMPANY SALES

These will be determined by four decisions:-

1. Price

At present, your company is charging £9-15-1 for the quality of product which it is selling. Price may be freely raised or lowered, however, higher prices will tend to lead to a lower market share, assuming constant quality. GRIMLETS are available to your customer for £17 and they are considered to be superior in every way.

2. Quality

The same as decision 2 above.

3. Selling Expense.

This item includes the hiring, training, and services of salesmen.

4. Technical Information Service.

This pays for the preparation and dissemenation, including advertising, of the technical data concerning the abilities and advantages of your companies WIDGETS.

The referee will indicate the market share achieved by your Company after each set of decisions.

Other market research information will be made available from time to time, some of which will only be available for sale.

ENGINEERING EMPLOYERS' WEST OF ENGLAND ASSOCIATION

SIMULATION TRAINING EXERCISE

"WEST"

OPERATING STATEMENTS

Team C. Period 15

COSTS	£		
Production	6525		
Plant Administration	2800		
Maintenance	450	9775	
Stock Holding	246		
Selling Expense	1300		
Tech. Info. Service	1300		
Hire Purchase	500		
Others			
TOTAL	13121		

STOCK			
Opening Stock	756	4918	
Last Months Production	1500	9775	
Total	2256	14693	
Less Sales	1472	9600	
Closing Stock	784	5093	
Net Change			+ £ 175

CASH STATEMENT			
Opening Balance	10754		
Sales	13984		
Total	24738	24738	
Costs		13121	
Closing Balance		11617	
Net Change			+ £ 863
Profit or Loss.			+ £1038

"WEST"

DECISION FORM

Team C Period 15

Production Capacity Available	1500	UNITS
Production Quantity	1500	UNITS
Quality	60	%
Plant Administration (£1,000 min)	£ 2800	
Maintenance	£ 450	
Price	£ 19. 10. 0.	
Selling Expense	£ 1300	
Technical Information Service	£ 1300	
New Capacity Required		LINES

Units Cost	£ 4. 7. 0.	
Market Share	23.0	%

TEAM D. | SIMULATION TRAINING EXERCISE "WEST" | MDE.01.

This simulation exercise emphasises the planning elements of management. The simulation is intended to have the basic characteristics of the engineering industry. The product produced is a WIDGET. This is to prevent you, the participants, from trying to bring too much of your own experience into the game, or, far worse, to try to take specific lessons from the game and apply them in your job. The intention of the game is not to teach specific lessons but to dramatically highlight areas of planning in management.

Although each Company starts from a different finanical and trading position they all operate within the same set of conditions and are covered by the same environment, it is obvious that the best performance will derive from the 'best' decisions made. This exercise then is a severe test of the participants ability to understand, analyse and interpret the information available in the conditions prevailing and the situations developing throughout the exercise. This is precisely the same situation in which a manager finds himself in 'real life': these are the functions he performs every day.

You will find that many elements in this simulation are vastly simplified as compared to the 'real life' environment in which you work. This is to allow you, as participants, to concentrate your attention on a few elements in the decision making process which we will consider as critical during the course of this exercise. These elements are indicated below:-

Your company has a factory costing £30,000 (hire purchase charge £250/month) capable of holding 6 production lines. There are 4 production lines installed, each costing £12,000 (hire purchase charge £100/line/month) — line is wholly owned by the Company, 4 are on hire purchase. There is a ready market for scrap lines at £3,500 each outside your marketing area. If you wish to dispose of a line, therefore, you may sell to this outside interest through the umpire or you may negotiate it's sale to one of your competitors. The vendor will, however, still be liable for the remaining 5 years of the H.P. agreement (10 years have been paid) unless he transfers this liability. New lines are available from the umpire on 3 months notice. They cost £12,000 or £100/month for 15 years. Any H.P. agreement can be terminated by paying 90 per cent of the balance owing. Each production line is capable of producing 250 WIDGETS/month.

UNIT COST OF PRODUCTION.

1. Production Quantity.

Your company has a factory with a present capacity of producing 1000 WIDGETS per month. The plant can always be run at capacity plus 25% to minus 50%, It will be most economical in terms of unit cost of production to run the plant exactly at capacity and the greater the deviation the greater the increase in unit cost of production.

2. Quality.

It is difficult to define this decision clearly, but it refers to quality consciousness, time taken in production, the presentation of the product etc. Last year the quality of the product was 90% (100% is perfect) but this can be raised or lowered. This will, of course, affect unit cost of production but will also have a major affect upon the sale-ability of your product.

3. Plant Administration.

These are the overheads of running your firm. The minimum expenditure is £1,000 per month, but during the past year you have spent £2000 per month. Raising this expenditure will lower the direct unit costs of production but will raise the overheads and therefore analysis is needed to determine the point of diminishing returns.

4. Maintenance.

The Company is now spending £550 per month maintaining its plant. There is, however, no reason to assume that this is the optimum expenditure. Increase in maintenance expenditure will lower direct unit cost of production but may raise the total cost of production. This expenditure must be related to total capacity available and the use there-of.

The raw materials are widely available, and will be delivered as needed and their cost included in the direct unit cost of production. This and other rules are made to simplify bookkeeping.

There will be a charge for holding stock equal to 5% of the value of stock on the first of each month.

The standard direct unit cost of production is £5-11-11 per unit. The decisions which you make can either raise or lower this standard cost and this information will be given to you by the referee after each decision.

COMPANY SALES

These will be determined by four decisions:-

1. Price

At present, your company is charging £11-5-1 for the quality of product which it is selling. Price may be freely raised or lowered, however, higher prices will tend to lead to a lower market share, assuming constant quality. GRIMLETS are available to your customer for £17 and they are considered to be superior in every way.

2. Quality

The same as decision 2 above.

3. Selling Expense.

This item includes the hiring, training, and services of salesmen.

4. Technical Information Service.

This pays for the preparation and dissemenation, including advertising, of the technical data concerning the abilities and advantages of your companies WIDGETS.

The referee will indicate the market share achieved by your Company after each set of decisions.

Other market research information will be made available from time to time, some of which will only be available for sale.

ENGINEERING EMPLOYERS' WEST OF ENGLAND ASSOCIATION

DEPARTMENT OF WORK STUDY & STAFF TRAINING

SIMULATION TRAINING EXERCISE
"WEST"

OPERATING STATEMENTS

Team D Period 15

COSTS	£		
Production	5850		
Plant Administration	2000		
Maintenance	550	8400	
Stock Holding	544		
Selling Expense	1500		
Tech.Info.Service	500		
Hire Purchase	650		
Others	-		
TOTAL	11,594		

STOCK	Units	£	
Opening Stock	1257	10486	
Last Months Production	1000	8400	
Total	2257	18886	
Less Sales	1216	10170	
Closing Stock	1041	8716	
Net Change			-£1770

CASH STATEMENT			
Opening Balance	6967		
Sales	13680		
Total	20647	20647	
Costs		11594	
Closing Balance		9053	
Net Change			+£2086
Profit or Loss			+£316

"WEST"

DECISION FORM

Team D Period 15

Production Capacity Available	1000	UNITS
Production Quantity	1000	UNITS
Quality	90	%
Plant Administration (£1,000 min.)	£ 2000	
Maintenance	£ 550	
Price	£ 11. 5. 0	
Selling Expense	£ 1500	
Technical Information Service	£ 500	
New Capacity Required		LINES

Units Cost	£ 5. 17. 0	
Market Share	19. 0.	%

TEST SCALES

In Chapter 8 I discussed a development of the test scale used in this exercise. The instructions given to each participant on the cover of the questionnaire indicated the format of the test.

This document contains 63 statements. None are necessarily true; none are necessarily false. They conceal no hidden meanings; none are catches. Would you please show under each item what your opinion is by ringing in the appropriate letters?

SA means strongly agree

A means agree or tend toagree

U means uncertain or undecided

D means disagree

SD means strongly disagree.

Example: A good manager constantly retrains himself.

SA A U D SD

These questionnaires were issued only to participants who had completed the full exercise. Each participant made the decision to attend the game individually, that

* In Chapters 10, 11 and 12 the common practice of using the scale 5, 4, 3, 2 1 has been adopted. The question arises, of course, of the sensitivity of the results obtained to the scale employed. This matter is dealt with in Appendix V.

is - there was no coercion either on the part of his employers or the association. The training officers of each association also stated that by and large the participants were people who were actively interested in management training. Taking these two statements together, I have assumed that the vast majority of the respondents would be qualified to give their attitude towards every statement.

I list below the 63 items in the questionnaire:

1. The game revealed a number of problem areas for me which I have subsequently pursued.

2. I would have gained more participating in a case study.

3. There has been no change in my approach to management problems.

4. The games were a source of mental stimulation to me.

5. Most conversation concerning the game since participation was either fact or opinion rather than an attempt to appraise the value or use of the game or any part of it.

6. The game would have had a better reception, had participants been given more information about the nature and purpose of the exercise.

7. I learned a new way to handle management information.

8. Had the model been more complex, it would have been more useful as I work in a highly complex environment.

9. Once the players can spot the mathematics of the model in the computer, they can perform well irrespective of whether or not they can manage.

10. Experience of the game has taught me to pay more attention to correcting the consequences of faulty decisions in my normal work.

11. A game is not the best way to use a two day training meeting in our industry.

12. I found my main learning occurred after the end of the exercise when examining my behaviour and reactions.

13. While there might have been some benefit derived from participating in this business game, there is certainly no need to repeat the exercise.

14. The younger participants appeared to be more earnest.

15. The game would have been more useful for trainees first coming into the industry than for the group with which it was used.

16. Having regard to the time that can reasonably be spent on preparing for and participating in the game, it offers a close resemblance to real life situations.

17. I maintained a high degree of interest throughout the exercise.

18. The game was the most useful two days' management training I have ever had.

19. This game would have been of greater benefit had it been built around the training needs of the individual player.

20. There was a marked rivalry between the teams.

21. By being forced to accept responsibility for a job outside my own functional speciality, I broadened my outlook on management problems.

22. Fortuitous events caused loss of profits and thus led to ruffled feelings.

23. Playing games is a waste of time.

24. After the time elapsed I cannot find any area of improvement in my management ability attributable to the game.

25. I am more alive to the use I can make of information that can be got from other departments.

26. The results of the game do not in any way indicate who are the best managers.

27, The exercise appeared to distress the older participants.

28. Its inclusion in a formal course of management training would not have enhanced the value of the game.

29. The exercise was of no value to the participants.

30. The game gave me no additional insight into my process of decision taking.

31. The conduct of the game by the organisers aided its usefulness to me.

32. At the end of the game I had less confidence in my ability to manage than before it started.

33. The fact that I was able to examine my behaviour in a management situation not linked to my day-to-day job was most useful.

34. The model was too complex to expect me to make any useful analysis of it.

35. The participants showed pleasure in assuming the role of top management.

36. My use of information has been uneffected by participation.

37. I would have grown as much in management ability by reading a good book on management.

38. The structure of the game was such that it did not consider many important variables in an industrial situation.

39. The effect of the game in getting participants to work with one another and to understand points of view different from their own has been beneficial.

40. Overall, I had an unfavourable reaction to this new experience.

41. There has been a positive change in my ability to take logical decisions.

42. The fact that many problems in the game could have been solved by statistical analysis made the game more useful.

43. There was an area of learning in the human relations field which could not have been shown to me more forcibly by any other technique of management training.

44. I found the game extremely enjoyable.

45. The exercise and my examination of it helped to develop new concepts related to decision taking.

46. No real money was involved so that the teams tended to make reckless decisions.

47. The game offered me the opportunity to exercise management skills rarely used in my jobs.

48. A new second game would be valuable to me.

49. The teams weren't given enough time to make reasoned decisions.

50. Once involved I felt the simulation was realistic enough to demand my constant attention during the game sessions.

51. The game should probably be used as a test of the participant's ability rather than as a training tool.

52. The game has had a more lasting impact on my management thinking than any other short management training programme which I have participated in.

53. I find that I still recall some incident in the game occasionally in a management context.

54. The only benefit of the game is that it offers an attractive alternative to work.

55. Participating has made me realise the need to assess the information which is available.

56. There seemed to be enough information available for the teams to make reasoned decisions.

57. A two day course of lectures on a management subject would have been of greater value.

58. The exercise physically exhausted me.

59. The lessons of the game offered me no help in solving day-to-day problems.

60. I adopted the attitude, "It's only a game", and acted accordingly.

61. Games are an impractical method of management training.

62. Although the results of each decision follow strictly from the logic of the situation, the game nevertheless offers a sensitive opportunity to study human relations through the interactions within each team.

63. I would not recommend my fellow managers to participate in a similar exercise.

It will be noted that about half the items are put in a negative format. This is to ensure that results were not artificially created by ringing all the agrees or disagrees - that is acquiescence by the respondent. It forces the respondent into carefully considering each question and further reinforces the strong positive results gained from the analysis of variance below. I therefore list below the 63 statements as they were read for analysis.

Wherever a statement was inverted, the answers of course were inverted as well:

1. The game revealed a number of problem areas for me which I have subsequently pursued.

2. I would have gained less participating in a case study.

3. There has been a change in my approach to management problems.

4. The games were a source of mental stimulation to me.

5. Most conversation concerning the game since participation was an attempt to appraise the value or use of the game or any part of it, rather than merely fact or opinion.

6. The game could not have had a better reception, had participants been given more information about the nature and purpose of the exercise.

7. I learned a new way to handle management information.

8. Although I work in a highly complex environment the game need not be more complex to be useful.

9. Even if the players can spot the mathematics of the model in the computer, they cannot perform well unless they can manage.

10. Experience of the game has taught me to pay more attention to correcting the consequences of faulty decisions in my normal work.

11. A game is the best way to use a two day training meeting in our industry.

12. I found my main learning occurred after the end of the exercise when examining my behaviour and reactions.

13. I have had some benefit from participating in this business game and feel there is need to repeat the exercise.

14. All participants appeared to be equally earnest.

15. The game was as useful for the group with which it was used as it would be for training people coming into the industry.

16. Having regard to the time that can reasonably be spent on preparing for and participating in the game, it offers a close resemblance to real life situations.

17. I maintained a high degree of interest throughout the exercise.

18. The game could not have been of greater benefit had it been built around the training needs of the individual player.

19. This game was the most useful two days' management training I have ever had.

20. There was a marked rivalry between the teams.

21. By being forced to accept responsibility for a job outside my own functional speciality, I broadened my outlook on management problems.

22. Loss of profits and ruffled feelings can be attributed to fortuitous events.

23. Playing games is not a waste of time.

24. After the time elapsed I can find area of improvement in my management ability attributable to the game.

25. I am more alive to the use I can make of information that can be got from other departments.

26. The results of the game do indicate who are the best managers.

27. The exercise did not appear to distress the older participants.

28. Its inclusion in a formal course of management training would have enhanced the value of the game.

29. The exercise was of value to the participants.

30. The game gave me additional insight into my process of decision taking.

31. The conduct of the game by the organisers aided its usefulness to me.

32. At the end of the game I had more confidence in my ability to manage than before it started.

33. The fact that I was able to examine my behaviour in a management situation not linked to my day-to-day job was most useful.

34. The model was not too complex to expect me to make any useful analysis of it.

35. The participants showed pleasure in assuming the role of top management.

36. My use of information has been affected by participation.

37. I would not have grown as much in management ability by reading a good book on management.

38. The structure of the game was such that it considered many important variables in an industrial situations.

39. The effect of the game in getting participants to work with one another and to understand points of view different from their own has been beneficial.

40. Overall, I had a favourable reaction to this new experience.

41. There has been a positive change in my ability to take logical decisions.

42. The fact that many problems in the game could have been solved by statistical analysis made the game more useful.

43. There was an area of learning in the human relations field which could not have been shown to me more forcibly by any other technique of management training.

44. I found the game extremely enjoyable.

45. The exercise and my examination of it helped to develop new concepts related to decision taking.

46. Although real money was not involved the teams did not tend to make reckless decisions.

47. The game offered me the opportunity to exercise management skills rarely used in my jobs.

48. A new second game would be valuable to us.

49. The teams were given enough time to make reasoned decisions.

50. Once involved I felt the simulation was realistic enough to demand my constant attention during the game sessions.

51. The game is better used as a training tool than as a test of the participants' ability.

52. The game has had a more lasting impact on my management thinking than any other short management training programme.

53. I find that I still recall some incident in the game occasionally in a management context.

54. The fact that it offers an attractive alternative to work is not the only benefit of the game.

55. Participating has made me realise the need to assess the information which is available.

56. There seemed to be enough information available for the teams to make reasoned decisions.

57. A two day course in lectures on a management subject would not have been of greater value.

58. The exercise did not exhaust me.

59. The lessons of the game offered me help in solving day-to-day problems.

60. I did not adopt the attitude, "It's only a game", and acted accordingly.

61. Games are a practical method of management training.

62. Although the results of each decision follow strictly from the logic of the situation, the game nevertheless offers a sensitive opportunity to study human relations through the interactions within the teams.

63. I would recommend my fellow managers to participate in a similar exercise.

C H A P T E R 10

THE VALIDITY OF THE TEST AND RESULTS

There were three basic types of analysis which I decided to attempt in studying the data provided by the test.

1. Correlation
2. Factor Analysis
3. Analysis of Variance.

MEANS

Below are listed the mean scores in answer to each question from the total population studied, all engineers and all printers. I also include the grand means for each individual group which participated, which clearly shows a significant difference for Engineers Group 2. This indicates that either the groupswere so imperfectly selected as to yield this significant difference, or that the difference is due to the difference in the experience that the participants are responding to. I am sure that it is the latter. There were 75 engineers and 144 printers.

MEANS AND STANDARD DEVIATIONS - ALL DATA

VARIABLE	MEAN	SD	VARIABLE	MEAN	SD	VARIABLE	MEAN	SD
1	2.969	0.997	2	3.175	1.003	3	3.067	1.068
4	4.464	0.653	5	3.103	1.048	6	2.985	1.298
7	2.871	0.992	8	3.711	1.028	9	2.582	1.036
10	3.139	0.953	11	3.397	1.102	12	3.541	0.950
13	3.175	1.161	14	3.371	1.001	15	3.948	0.813
16	3.351	1.003	17	4.407	0.744	18	3.144	1.133
19	2.851	1.135	20	4.237	0.745	21	3.505	0.967
22	3.268	1.038	23	4.294	0.763	24	3.216	0.963
25	3.325	0.912	26	2.490	1.064	27	3.701	0.918
28	3.376	0.980	29	4.284	0.739	30	3.557	1.013
31	3.784	0.716	32	3.840	0.882	33	3.902	0.724
34	4.031	0.712	35	3.696	0.772	36	3.201	0.879
37	3.495	1.064	38	2.448	0.971	39	4.026	0.631
40	4.098	0.931	41	2.763	0.818	42	3.330	0.730
43	2.835	1.050	44	4.289	0.781	45	3.216	0.902
46	3.155	1.190	47	3.247	1.038	48	3.443	0.981
49	3.124	1.154	50	4.160	0.748	51	3.665	0.980
52	3.062	1.085	53	3.139	1.021	54	4.227	0.814
55	3.804	0.865	56	3.598	0.829	57	3.443	0.955
58	3.876	0.984	59	3.222	1.022	60	4.026	0.804
61	4.005	0.765	62	3.840	0.815	63	4.062	1.021

MEANS AND STANDARD DEVIATIONS — ENGINEERS

VARIABLE	MEAN	SD	VARIABLE	MEAN	SD	VARIABLE	MEAN	SD
1	3.027	1.039	2	3.240	0.998	3	3.200	1.151
4	4.480	0.578	5	3.280	1.047	6	3.080	1.333
7	2.920	1.024	8	3.573	1.042	9	2.600	1.078
10	3.147	1.036	11	3.253	1.079	12	3.547	0.949
13	2.787	1.106	14	3.293	1.075	15	3.880	1.065
16	3.293	1.136	17	4.467	0.759	18	3.187	1.159
19	2.827	1.178	20	4.333	0.684	21	3.573	0.975
22	3.307	1.052	23	4.307	0.788	24	3.440	0.990
25	3.387	1.038	26	2.600	1.151	27	3.680	1.002
28	3.227	1.047	29	4.307	0.716	30	3.653	1.033
31	3.707	0.749	32	3.973	0.822	33	3.893	0.764
34	4.147	0.651	35	3.653	0.862	36	3.373	0.897
37	3.680	1.129	38	2.373	1.010	39	3.987	0.726
40	4.107	0.981	41	2.787	0.890	42	3.293	0.712
43	3.067	1.107	44	4.347	0.780	45	3.213	0.963
46	3.453	1.154	47	3.160	1.139	48	3.213	0.934
49	3.200	1.162	50	4.200	0.854	51	3.640	0.954
52	3.067	1.095	53	3.280	1.021	54	4.240	0.768
55	3.760	1.025	56	3.640	0.816	57	3.467	1.031
58	3.693	1.090	59	3.293	1.050	60	4.067	0.844
61	3.947	0.715	62	3.947	0.634	63	3.973	1.150

MEANS AND STANDARD DEVIATIONS — PRINTERS

VARIABLE	MEAN	SD	VARIABLE	MEAN	SD	VARIABLE	MEAN	SD
1	2.933	0.972	2	3.134	1.008	3	2.983	1.008
4	4.454	0.698	5	2.992	1.037	6	2.924	1.277
7	2.840	0.974	8	3.798	1.013	9	2.571	1.013
10	3.134	0.901	11	3.487	1.111	12	3.538	0.955
13	3.420	1.131	14	3.420	0.952	15	3.992	0.604
16	3.387	0.912	17	4.370	0.735	18	3.118	1.121
19	2.866	1.112	20	4.176	0.777	21	3.462	0.964
22	3.244	1.033	23	4.286	0.749	24	3.076	0.922
25	3.286	0.825	26	2.420	1.004	27	3.714	0.865
28	3.471	0.928	29	4.269	0.756	30	3.496	0.999
31	3.832	0.693	32	3.756	0.911	33	3.908	0.701
34	3.958	0.741	35	3.723	0.712	36	3.092	0.854
37	3.378	1.008	38	2.496	0.947	39	4.050	0.565
40	4.092	0.902	41	2.748	0.773	42	3.353	0.743
43	2.689	0.989	44	4.252	0.784	45	3.218	0.865
46	2.966	1.178	47	3.303	0.970	48	3.588	0.986
49	3.076	1.151	50	4.134	0.676	51	3.681	0.999
52	3.059	1.084	53	3.050	1.016	54	4.218	0.845
55	3.832	0.751	56	3.571	0.839	57	3.429	0.907
58	3.992	0.897	59	3.176	1.005	60	4.000	0.781
61	4.042	0.796	62	3.773	0.906	63	4.118	0.931

GROUP GRAND MEANS

FOR ALL VARIABLES

ENGINEERS	GROUP	1	3.521
		2	3.153
		3	3.703
		4	3.765
PRINTERS	GROUP	1	3.593
		2	3.347
		3	3.413
		4	3.567
		5	3.433
		6	3.573

RANK CORRELATION OF MEAN SCORES FOR ALL 63 VARIABLES

ALL PRINTERS/ALL ENGINEERS

	P	E			P	E			P	E	
1	8	8	0	22	23	28	5	43	4	9	5
2	20	20	0	23	61	59	2	44	59	61	2
3	11	15	4	24	15	31	16	45	22	17	5
4	63	63	0	25	24	30	6	46	10	32	22
5	12	22	10	26	1	2	1	47	25	13	12
6	7	11	4	27	40	42	2	48	38	18	20
7	6	7	1	28	33	19	14	49	16	16	0
8	44	36	8	29	60	58	2	50	56	56	0
9	3	3	0	30	35	40	5	51	39	37	2
10	19	12	7	31	45	44	1	52	14	10	4
11	34	21	13	32	42	51	9	53	13	23	10
12	36	24	12	33	47	47	0	54	58	57	1
13	30	5	25	34	48	55	7	55	46	45	1
14	29	14	15	35	41	39	2	56	37	38	1
15	50	46	4	36	17	29	12	57	31	33	2
16	28	27	1	37	27	41	14	58	49	43	6
17	62	62	0	38	2	1	1	59	21	25	4
18	18	14	4	39	53	52	1	60	51	53	2
19	7	6	1	40	54	54	0	61	52	49	3
20	57	60	3	41	5	4	1	62	43	48	5
21	32	35	3	42	26	24	2	63	55	50	5

$$r = 1 - \frac{6 \times 3680}{62 \times 63 \times 64}$$

$$= 1 - \frac{345}{3906} = +0.912$$

Rank correlation analysis of these mean soores gives an "r" value of +0.912.

Considering the fact that these two groups never met each other and they participated in exercises of vastly different intensity, this is an exceptionally high correlation coefficient to find between groups. To have achieved this figure, it would seem that either both these universes of participants have substantially the same attitudes towards management games and their usefulness, or alternatively, that the questionnaire is measuring something about which all managers tend to agree completely, irrespective of the industry in which they work or the training which they have received.

All the tests for the internal validity of the questionnaire shown in this chapter and the next will prove that the former is, in fact, the reason for this high correlation coefficient.

For all the further analysis of validity which I did, I concentrated on items which were indicated as key items by factor analysis.

CORRELATION COEFFICIENTS

Correlation Coefficients by the "product moment" method were calculated for the total population.

CORRELATION MATRIX — ALL DATA

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	0.156	0.493	0.221	0.122	-0.056	0.478	0.082	0.233	0.523	0.266	0.165
2	0.156	1.000	0.366	0.168	0.269	0.201	0.049	0.160	0.001	0.229	0.406	0.030
3	0.493	0.366	1.000	0.134	0.202	0.034	0.380	0.126	0.096	0.398	0.307	0.163
4	0.221	0.168	0.134	1.000	0.157	0.241	0.253	0.131	0.119	0.279	0.247	0.228
5	0.122	0.269	0.202	0.157	1.000	0.161	0.133	0.052	0.026	0.157	0.193	-0.072
6	-0.056	0.201	0.034	0.241	0.161	1.000	0.019	-0.027	0.192	0.060	0.062	0.019
7	0.478	0.049	0.380	0.253	0.133	0.019	1.000	0.085	0.251	0.458	0.199	0.223
8	0.082	0.160	0.126	0.131	0.052	-0.027	0.085	1.000	0.086	0.052	0.102	0.023
9	0.233	0.001	0.096	0.119	0.026	0.192	0.251	0.086	1.000	0.175	0.141	0.104
10	0.523	0.229	0.398	0.279	0.157	0.060	0.458	0.052	0.175	1.000	0.322	0.243
11	0.266	0.406	0.307	0.247	0.193	0.062	0.199	0.102	0.141	0.322	1.000	0.139
12	0.165	0.030	0.163	0.228	-0.072	0.019	0.223	0.023	0.104	0.243	0.139	1.000
13	0.278	0.361	0.266	0.323	0.151	0.105	0.204	0.051	0.246	0.315	0.431	0.172
14	-0.025	0.064	0.064	0.108	0.205	0.168	0.080	0.074	0.065	-0.022	0.087	0.027
15	0.171	0.265	0.261	0.133	0.134	0.048	0.159	0.069	0.067	0.264	0.347	0.117
16	0.286	0.356	0.384	0.257	0.212	0.159	0.311	0.104	0.186	0.328	0.450	0.110
17	0.178	0.202	0.187	0.473	0.245	0.275	0.219	0.012	0.101	0.234	0.269	0.236
18	0.114	0.329	0.215	0.098	0.232	0.375	0.030	0.178	0.232	0.173	0.290	0.033
19	0.243	0.205	0.256	0.339	0.179	0.104	0.346	0.043	0.136	0.340	0.491	0.196
20	0.115	0.027	0.032	0.220	-0.051	0.052	0.147	0.029	0.062	0.216	0.093	0.067
21	0.247	0.165	0.243	0.226	0.056	0.138	0.387	0.121	0.181	0.339	0.253	0.203
22	0.003	0.064	0.026	0.014	0.065	0.199	0.044	0.019	-0.001	-0.116	-0.007	-0.059
23	0.339	0.339	0.383	0.360	0.163	0.183	0.345	0.188	0.123	0.300	0.520	0.187
24	0.509	0.309	0.465	0.161	0.235	0.098	0.415	0.022	0.257	0.537	0.363	0.256
25	0.325	0.068	0.206	0.172	0.014	-0.105	0.327	-0.071	0.095	0.460	0.247	0.197
26	0.337	0.206	0.372	0.193	0.154	0.114	0.261	0.016	0.182	0.331	0.342	0.188
27	-0.021	0.007	-0.001	0.060	0.054	0.140	-0.043	0.133	0.135	-0.065	0.056	0.032
28	0.044	0.038	-0.004	0.098	0.108	0.078	0.050	0.103	0.074	0.060	0.053	0.153
29	0.357	0.387	0.357	0.370	0.230	0.145	0.347	0.204	0.264	0.378	0.440	0.238
30	0.500	0.378	0.521	0.274	0.312	0.117	0.407	0.066	0.272	0.510	0.418	0.245
31	0.114	0.060	0.046	0.249	0.071	0.141	0.223	0.112	0.227	0.242	0.201	0.074
32	-0.188	0.032	-0.137	0.066	0.124	-0.002	0.006	-0.164	-0.056	-0.020	0.018	0.023
33	0.340	0.302	0.310	0.371	0.095	0.169	0.394	0.226	0.318	0.441	0.380	0.273
34	0.118	0.290	0.222	0.170	0.308	0.264	0.138	-0.165	0.032	0.248	0.266	0.159
35	0.149	0.230	0.188	0.271	0.001	0.099	0.206	0.137	0.054	0.213	0.216	-0.022
36	0.527	0.277	0.468	0.243	0.214	0.007	0.434	0.099	0.320	0.511	0.377	0.229
37	0.298	0.389	0.335	0.235	0.163	0.148	0.296	0.183	0.231	0.341	0.440	0.175
38	0.179	0.249	0.166	0.120	0.000	0.100	0.189	0.286	0.233	0.184	0.254	0.123
39	0.199	0.148	0.220	0.122	0.098	0.108	0.179	0.165	0.127	0.158	0.283	0.115
40	0.216	0.350	0.244	0.343	0.197	0.276	0.306	0.106	0.215	0.259	0.457	0.162
41	0.404	0.196	0.362	0.188	0.198	-0.038	0.377	0.140	0.097	0.382	0.352	0.193
42	0.035	0.109	0.025	0.177	-0.031	0.071	0.116	-0.045	0.094	0.068	0.080	0.100
43	0.134	0.279	0.172	0.135	0.176	0.139	0.159	0.056	0.094	0.308	0.258	0.168
44	0.151	0.250	0.163	0.478	0.191	0.275	0.209	-0.044	0.041	0.210	0.330	0.172
45	0.503	0.284	0.431	0.295	0.086	0.069	0.512	0.135	0.142	0.447	0.382	0.340
46	0.161	0.251	0.232	0.101	0.288	0.240	0.197	0.083	0.082	0.214	0.139	0.141
47	0.168	0.033	0.223	0.250	0.034	0.022	0.283	0.019	0.029	0.227	0.208	0.063
48	0.365	0.321	0.258	0.405	0.122	0.152	0.362	0.097	0.157	0.416	0.368	0.208
49	0.084	0.227	0.069	0.130	0.101	0.430	0.127	-0.048	0.108	0.097	0.185	-0.037
50	0.166	0.232	0.188	0.378	0.230	0.180	0.272	0.121	0.260	0.230	0.262	0.098
51	0.074	0.261	0.264	0.074	0.236	0.183	0.073	0.228	0.163	0.122	0.143	0.029
52	0.342	0.185	0.327	0.318	0.218	0.056	0.301	0.207	0.171	0.398	0.460	0.209
53	0.361	0.199	0.343	0.167	0.112	0.064	0.340	0.157	0.222	0.443	0.291	0.264
54	0.258	0.329	0.328	0.250	0.179	0.121	0.242	0.240	0.260	0.233	0.332	0.262
55	0.257	0.189	0.328	0.134	-0.006	0.025	0.290	0.064	0.093	0.486	0.190	0.186
56	0.185	0.328	0.212	0.222	0.167	0.288	0.138	0.143	0.141	0.294	0.266	0.107
57	0.385	0.503	0.448	0.392	0.213	0.215	0.312	0.158	0.230	0.405	0.581	0.203
58	0.091	-0.099	-0.076	0.041	0.073	0.104	0.010	-0.143	0.056	-0.020	0.036	0.028
59	0.460	0.341	0.551	0.195	0.167	0.073	0.351	0.076	0.249	0.484	0.395	0.217
60	0.163	0.277	0.185	0.155	0.237	0.119	0.069	0.097	0.181	0.137	0.216	0.043
61	0.143	0.309	0.266	0.306	0.206	0.183	0.117	0.147	0.147	0.255	0.383	0.146
62	0.019	0.142	0.084	0.257	0.141	0.061	0.167	0.087	0.025	0.169	0.146	0.112
63	0.297	0.430	0.386	0.291	0.173	0.130	0.325	0.200	0.122	0.380	0.439	0.243

	13	14	15	16	17	18	19	20	21	22	23	24
1	0.278	-0.025	0.171	0.286	0.178	0.114	0.243	0.115	0.247	0.003	0.339	0.509
2	0.361	0.064	0.265	0.356	0.202	0.329	0.205	0.027	0.165	0.064	0.339	0.309
3	0.266	0.064	0.261	0.384	0.187	0.215	0.256	0.032	0.243	0.026	0.383	0.465
4	0.323	0.108	0.133	0.257	0.473	0.098	0.339	0.220	0.226	0.014	0.360	0.161
5	0.151	0.205	0.134	0.212	0.245	0.232	0.179	-0.051	0.056	0.065	0.163	0.235
6	0.105	0.168	0.048	0.159	0.275	0.375	0.104	0.052	0.138	0.199	0.183	0.098
7	0.204	0.080	0.159	0.311	0.219	0.030	0.346	0.147	0.387	0.044	0.345	0.415
8	0.051	0.074	0.069	0.104	0.012	0.178	0.043	0.029	0.121	0.019	0.188	0.022
9	0.246	0.065	0.067	0.186	0.101	0.232	0.136	0.067	0.181	-0.001	0.123	0.257
10	0.315	-0.022	0.264	0.328	0.234	0.173	0.340	0.216	0.339	-0.116	0.300	0.537
11	0.431	0.087	0.347	0.450	0.269	0.290	0.491	0.093	0.253	-0.007	0.520	0.363
12	0.172	0.027	0.117	0.110	0.236	0.033	0.196	0.067	0.203	-0.059	0.187	0.256
13	1.000	0.055	0.301	0.339	0.277	0.174	0.342	0.054	0.230	-0.125	0.445	0.374
14	0.055	1.000	0.151	0.118	0.067	0.167	-0.028	-0.014	0.105	0.018	0.094	0.034
15	0.301	0.151	1.000	0.321	0.163	0.031	0.295	0.046	0.112	0.053	0.334	0.233
16	0.339	0.118	0.321	1.000	0.356	0.311	0.460	0.062	0.303	0.113	0.528	0.420
17	0.277	0.067	0.163	0.356	1.000	0.213	0.379	0.255	0.310	0.140	0.409	0.281
18	0.174	0.167	0.031	0.311	0.213	1.000	0.186	-0.090	0.122	0.143	0.154	0.280
19	0.342	-0.028	0.295	0.460	0.379	0.186	1.000	0.165	0.288	-0.076	0.350	0.385
20	0.054	-0.014	0.046	0.062	0.255	-0.090	0.165	1.000	0.164	-0.183	0.150	0.087
21	0.230	0.105	0.112	0.303	0.310	0.122	0.288	0.164	1.000	-0.058	0.353	0.394
22	-0.125	0.018	0.053	0.113	0.140	0.143	-0.076	-0.183	-0.058	1.000	0.044	-0.032
23	0.445	0.094	0.334	0.528	0.409	0.154	0.350	0.150	0.353	0.044	1.000	0.350
24	0.374	0.034	0.233	0.420	0.281	0.280	0.385	0.087	0.394	-0.039	0.350	1.000
25	0.142	-0.014	0.030	0.215	0.163	0.070	0.252	0.115	0.400	-0.081	0.212	0.504
26	0.249	0.038	0.107	0.372	0.185	0.258	0.267	-0.056	0.277	0.068	0.269	0.468
27	0.035	0.432	0.049	-0.049	0.103	0.062	-0.113	0.059	0.013	0.014	0.060	0.068
28	0.233	0.068	-0.028	0.050	0.229	0.030	0.037	0.118	0.126	-0.084	0.126	0.012
29	0.497	0.130	0.378	0.466	0.543	0.266	0.458	0.216	0.357	0.008	0.537	0.510
30	0.428	0.056	0.287	0.506	0.420	0.317	0.397	0.078	0.362	-0.029	0.495	0.561
31	0.220	0.084	-0.010	0.308	0.312	0.045	0.202	0.328	0.256	-0.089	0.256	0.279
32	-0.048	0.032	-0.084	-0.007	0.194	0.002	0.002	-0.021	-0.014	0.132	0.024	0.041
33	0.384	0.115	0.317	0.461	0.267	0.280	0.373	0.166	0.419	0.070	0.447	0.464
34	0.244	0.049	0.092	0.304	0.455	0.283	0.172	0.113	0.195	0.101	0.231	0.338
35	0.326	0.046	0.264	0.299	0.262	0.145	0.220	0.270	0.297	-0.189	0.258	0.173
36	0.288	0.068	0.210	0.407	0.262	0.267	0.300	0.101	0.288	-0.037	0.379	0.591
37	0.357	0.012	0.407	0.366	0.215	0.267	0.409	0.132	0.310	-0.036	0.452	0.436
38	0.197	0.036	0.095	0.317	0.183	0.261	0.291	-0.005	0.199	0.050	0.290	0.317
39	0.185	0.108	0.164	0.256	0.231	0.198	0.273	-0.112	0.259	0.116	0.264	0.247
40	0.392	0.103	0.315	0.429	0.491	0.217	0.387	0.123	0.319	0.101	0.551	0.398
41	0.224	0.007	0.130	0.279	0.168	0.149	0.230	0.050	0.375	-0.065	0.353	0.506
42	0.066	-0.012	0.072	0.146	0.142	0.009	0.194	0.141	0.115	-0.074	0.141	0.185
43	0.126	-0.104	0.124	0.296	0.140	0.177	0.262	0.050	0.312	-0.111	0.252	0.374
44	0.310	0.107	0.097	0.313	0.617	0.234	0.277	0.167	0.292	0.121	0.344	0.295
45	0.365	0.002	0.249	0.397	0.300	0.253	0.361	0.224	0.444	-0.118	0.412	0.465
46	0.160	0.117	0.115	0.202	0.221	0.229	0.209	0.058	0.161	0.096	0.216	0.287
47	0.235	0.101	0.070	0.240	0.244	0.049	0.282	0.192	0.350	-0.134	0.300	0.174
48	0.677	0.037	0.217	0.431	0.333	0.124	0.362	0.074	0.298	-0.026	0.469	0.359
49	0.146	0.081	-0.021	0.276	0.261	0.335	0.168	0.008	0.292	0.245	0.170	0.223
50	0.298	0.059	0.141	0.360	0.534	0.199	0.321	0.201	0.310	0.109	0.380	0.288
51	0.166	0.096	0.134	0.215	0.188	0.333	0.090	0.053	0.212	0.079	0.285	0.127
52	0.325	-0.050	0.321	0.423	0.309	0.186	0.668	0.180	0.370	-0.056	0.429	0.359
53	0.220	-0.015	0.152	0.382	0.177	0.247	0.349	0.263	0.311	-0.035	0.306	0.491
54	0.298	0.061	0.229	0.416	0.266	0.262	0.250	0.039	0.189	0.185	0.459	0.327
55	0.199	-0.071	0.236	0.294	0.189	0.087	0.218	0.153	0.354	-0.051	0.292	0.350
56	0.251	-0.000	0.192	0.307	0.292	0.305	0.250	0.147	0.190	0.186	0.344	0.304
57	0.500	0.087	0.404	0.530	0.452	0.381	0.530	0.121	0.362	0.078	0.598	0.510
58	0.042	0.026	0.083	0.055	0.189	-0.123	0.039	-0.066	0.001	0.164	0.090	-0.032
59	0.395	0.031	0.326	0.455	0.256	0.299	0.310	0.080	0.285	0.002	0.428	0.547
60	0.162	0.033	0.200	0.361	0.182	0.149	0.101	0.102	0.043	0.128	0.317	0.208
61	0.472	0.133	0.242	0.416	0.306	0.208	0.317	0.143	-0.179	0.037	0.530	0.343
62	0.150	-0.073	0.097	0.272	0.202	0.109	0.215	0.063	0.294	-0.035	0.268	0.203
63	0.511	0.084	0.428	0.495	0.362	0.229	0.366	0.103	0.320	0.072	0.602	0.408

	25	26	27	28	29	30	31	32	33	34	35	36
1	0.325	0.337	-0.021	0.044	0.357	0.500	0.114	-0.188	0.340	0.119	0.149	0.527
2	0.068	0.206	0.007	0.038	0.387	0.378	0.060	0.032	0.302	0.290	0.230	0.277
3	0.206	0.372	-0.001	-0.004	0.357	0.521	0.045	-0.137	0.310	0.222	0.188	0.468
4	0.172	0.193	0.060	0.098	0.370	0.274	0.249	0.066	0.371	0.170	0.271	0.243
5	0.014	0.154	0.054	0.108	0.230	0.312	0.071	0.124	0.095	0.308	0.001	0.214
6	-0.105	0.114	0.140	0.078	0.145	0.117	0.141	-0.002	0.169	0.264	0.099	0.007
7	0.327	0.261	-0.043	0.050	0.347	0.407	0.223	0.006	0.394	0.138	0.206	0.434
8	-0.071	0.016	0.133	0.103	0.204	0.066	0.112	-0.166	0.226	-0.165	0.137	0.099
9	0.075	0.182	0.135	0.074	0.264	0.272	0.227	-0.056	0.318	0.032	0.054	0.320
10	0.460	0.331	-0.065	0.060	0.378	0.510	0.242	-0.020	0.441	0.248	0.213	0.511
11	0.247	0.342	0.056	0.053	0.440	0.418	0.201	0.018	0.380	0.266	0.216	0.377
12	0.197	0.188	0.032	0.153	0.238	0.245	0.074	0.023	0.273	0.159	-0.022	0.229
13	0.142	0.249	0.035	0.233	0.497	0.428	0.220	-0.048	0.384	0.244	0.326	0.288
14	-0.014	0.038	0.432	0.068	0.130	0.056	0.084	0.032	0.115	0.049	0.046	0.068
15	0.030	0.107	0.049	-0.028	0.378	0.287	-0.010	-0.084	0.317	0.092	0.264	0.210
16	0.215	0.372	-0.049	0.050	0.466	0.506	0.308	-0.007	0.461	0.304	0.299	0.407
17	0.163	0.185	0.103	0.229	0.543	0.420	0.312	0.194	0.267	0.455	0.262	0.262
18	0.070	0.259	0.062	0.030	0.266	0.313	0.045	0.002	0.280	0.283	0.145	0.267
19	0.252	0.267	-0.113	0.037	0.458	0.397	0.202	0.002	0.373	0.172	0.220	0.300
20	0.115	-0.056	0.059	0.118	0.216	0.078	0.320	-0.021	0.168	0.113	0.270	0.101
21	0.400	0.277	0.013	0.126	0.357	0.362	0.256	-0.014	0.419	0.195	0.297	0.288
22	-0.081	0.068	0.014	-0.084	0.008	-0.029	-0.089	0.132	0.070	0.101	-0.189	-0.037
23	0.212	0.269	0.060	0.129	0.587	0.498	0.250	0.024	0.447	0.231	0.258	0.379
24	0.504	0.468	0.068	0.012	0.510	0.561	0.279	0.041	0.464	0.338	0.173	0.591
25	1.000	0.359	-0.075	0.031	0.278	0.376	0.172	0.052	0.331	0.096	0.141	0.455
26	0.359	1.000	-0.008	0.086	0.251	0.457	0.113	-0.021	0.332	0.260	0.100	0.492
27	-0.075	-0.008	1.000	0.062	0.133	-0.026	0.169	0.011	0.057	0.181	0.017	0.113
28	0.031	0.086	0.062	1.000	0.145	0.091	0.198	-0.116	0.038	0.102	0.070	0.038
29	0.278	0.251	0.133	0.145	1.000	0.577	0.332	0.006	0.488	0.348	0.379	0.454
30	0.376	0.457	-0.026	0.091	0.577	1.000	0.260	-0.022	0.534	0.357	0.297	0.543
31	0.172	0.113	0.169	0.198	0.332	0.260	1.000	-0.039	0.249	0.166	0.218	0.259
32	0.052	-0.021	0.011	-0.116	0.006	-0.022	-0.039	1.000	-0.017	0.165	-0.028	-0.092
33	0.331	0.332	0.057	0.038	0.488	0.534	0.249	-0.017	1.000	0.217	0.243	0.397
34	0.096	0.260	0.161	0.182	0.348	0.357	0.166	0.165	0.217	1.000	0.196	0.338
35	0.141	0.100	0.017	0.070	0.379	0.297	0.218	-0.028	0.243	0.196	1.000	0.266
36	0.455	0.492	0.113	0.038	0.454	0.543	0.259	-0.092	0.397	0.338	0.266	1.000
37	0.261	0.275	-0.044	-0.055	0.433	0.469	0.107	-0.092	0.447	0.192	0.241	0.425
38	0.262	0.448	0.047	0.078	0.277	0.340	0.103	0.012	0.313	0.047	0.176	0.343
39	0.174	0.189	0.148	0.068	0.295	0.261	0.207	-0.039	0.255	0.125	0.131	0.308
40	0.176	0.244	0.071	0.062	0.532	0.448	0.320	0.051	0.391	0.316	0.280	0.401
41	0.402	0.402	0.029	0.060	0.352	0.404	0.275	-0.089	0.293	0.173	0.263	0.364
42	0.126	0.104	0.016	0.072	0.162	0.080	0.217	-0.046	0.159	-0.010	0.096	0.085
43	0.332	0.277	-0.116	0.081	0.254	0.321	0.221	0.072	0.272	0.298	0.251	0.322
44	0.188	0.228	0.186	0.114	0.328	0.248	0.214	0.165	0.233	0.450	0.284	0.424
45	0.443	0.380	-0.057	0.060	0.475	0.503	0.153	-0.054	0.485	0.280	0.326	0.520
46	0.125	0.255	0.118	-0.015	0.297	0.341	0.064	0.063	0.300	0.300	0.035	0.728
47	0.221	0.002	0.045	-0.010	0.266	0.139	0.121	-0.019	0.301	0.151	0.353	0.155
48	0.232	0.277	-0.042	0.246	0.483	0.433	0.174	0.016	0.470	0.307	0.316	0.269
49	0.144	0.204	0.167	-0.059	0.183	0.211	0.202	0.132	0.213	0.311	0.130	0.139
50	0.235	0.272	0.022	0.101	0.442	0.436	0.336	0.062	0.412	0.244	0.255	0.266
51	-0.098	0.080	0.055	0.143	0.232	0.231	0.014	0.022	0.165	0.216	0.044	0.109
52	0.257	0.301	-0.132	0.061	0.463	0.412	0.171	-0.028	0.442	0.085	0.249	0.367
53	0.385	0.299	-0.049	0.061	0.394	0.476	0.247	-0.038	0.432	0.251	0.159	0.442
54	0.137	0.260	0.064	0.107	0.547	0.437	0.227	-0.043	0.416	0.184	0.116	0.365
55	0.370	0.262	-0.002	-0.078	0.249	0.332	0.140	-0.089	0.391	0.144	0.203	0.405
56	0.126	0.224	0.066	-0.030	0.407	0.336	0.211	0.039	0.366	0.346	0.214	0.295
57	0.227	0.443	-0.055	0.081	0.599	0.590	0.187	-0.032	0.498	0.407	0.317	0.474
58	-0.053	0.028	0.246	0.011	0.048	0.049	0.021	0.138	0.056	0.169	-0.009	-0.061
59	0.295	0.438	0.032	0.051	0.527	0.576	0.123	0.017	0.401	0.340	0.250	0.614
60	0.052	0.233	0.074	-0.071	0.284	0.337	0.118	0.123	0.280	0.234	0.186	0.278
61	0.116	0.213	0.194	0.108	0.483	0.344	0.163	0.040	0.375	0.247	0.248	0.314
62	0.259	0.192	-0.057	0.024	0.308	0.278	0.251	0.152	0.263	0.192	0.285	0.226
63	0.167	0.315	0.075	0.049	0.588	0.493	0.238	0.040	0.464	0.275	0.339	0.396

CORRELATION MATRIX — CONTINUED — ALL DATA

	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
1	0.298	0.170	0.199	0.216	0.404	0.035	0.134	0.151	0.503	0.161	0.168	0.305	0.884	0.166	0.074	0.342	0.361	0.258	0.257	0.185	0.385	0.091	0.460	0.163	0.143	0.010	0.267
2	0.380	0.249	0.148	0.359	0.196	0.185	0.279	0.259	0.284	0.291	0.033	0.321	0.227	0.232	0.261	0.185	0.199	0.325	0.189	0.328	0.503	-0.099	0.341	0.277	0.309	0.142	0.430
3	0.335	0.166	0.228	0.244	0.362	0.025	0.172	0.163	0.431	0.232	0.224	0.258	0.069	0.188	0.264	0.327	0.343	0.328	0.328	0.212	0.448	-0.076	0.551	0.185	0.266	0.084	0.386
4	0.238	0.120	0.122	0.343	0.188	0.077	0.135	0.478	0.295	0.181	0.258	0.405	0.130	0.378	0.074	0.310	0.167	0.250	0.134	0.272	0.392	0.041	0.195	0.158	0.306	0.259	0.291
5	0.163	0.088	0.090	0.197	0.198	-0.031	0.176	0.191	0.086	0.286	0.034	0.122	0.101	0.238	0.236	0.218	0.112	0.179	-0.006	0.167	0.213	0.073	0.167	0.237	0.206	0.141	0.173
6	0.148	0.188	0.198	0.276	-0.038	0.071	0.139	0.075	0.049	0.240	0.022	0.192	0.430	0.189	0.183	0.056	0.064	0.121	0.025	0.288	0.215	0.104	0.074	0.118	0.183	0.061	0.138
7	0.296	0.189	0.179	0.306	0.377	0.116	0.159	0.209	0.512	0.197	0.253	0.362	0.127	0.272	0.073	0.301	0.348	0.242	0.290	0.138	0.312	0.010	0.351	0.189	0.117	0.167	0.325
8	0.183	0.286	0.155	0.166	0.140	-0.045	0.056	-0.044	0.135	0.083	0.019	0.097	-0.048	0.121	0.228	0.207	0.157	0.240	0.064	0.143	0.158	-0.143	0.070	0.097	0.147	0.087	0.200
9	0.231	0.233	0.127	0.215	0.097	0.094	0.094	0.041	0.142	0.082	0.029	0.157	0.108	0.260	0.163	0.171	0.222	0.260	0.093	0.141	0.238	0.056	0.249	0.181	0.147	0.028	0.122
10	0.341	0.184	0.158	0.259	0.382	0.068	0.308	0.218	0.447	0.214	0.227	0.416	0.097	0.230	0.122	0.398	0.443	0.233	0.486	0.294	0.405	-0.020	0.484	0.137	0.255	0.160	0.380
11	0.446	0.254	0.283	0.457	0.352	0.088	0.258	0.330	0.382	0.138	0.208	0.368	0.185	0.262	0.143	0.460	0.291	0.332	0.196	0.266	0.580	0.036	0.395	0.216	0.385	0.146	0.489
12	0.175	0.123	0.115	0.162	0.193	0.100	0.168	0.172	0.340	0.141	0.063	0.208	-0.057	0.096	0.029	0.209	0.264	0.262	0.186	0.107	0.203	0.028	0.217	0.043	0.146	0.112	0.243
13	0.357	0.197	0.185	0.392	0.224	0.066	0.126	0.310	0.365	0.168	0.239	0.677	0.146	0.296	0.166	0.325	0.220	0.298	0.199	0.251	0.500	0.042	0.392	0.162	0.472	0.150	0.511
14	0.012	0.036	0.108	0.183	0.007	-0.012	-0.104	0.107	0.002	0.117	0.101	0.037	0.081	0.059	0.096	-0.858	-0.015	0.061	-0.871	-0.000	0.087	0.026	0.031	0.033	0.133	-0.073	0.084
15	0.407	0.095	0.164	0.315	0.130	0.072	0.124	0.097	0.249	0.115	0.070	0.217	-0.021	0.141	0.134	0.321	0.152	0.229	0.236	0.192	0.404	0.083	0.328	0.200	0.242	0.097	0.428
16	0.366	0.317	0.256	0.429	0.279	0.146	0.296	0.313	0.397	0.202	0.240	0.431	0.276	0.360	0.215	0.423	0.382	0.416	0.264	0.307	0.530	0.055	0.455	0.361	0.416	0.278	0.495
17	0.215	0.183	0.231	0.451	0.168	0.142	0.140	0.617	0.300	0.221	0.244	0.333	0.261	0.534	0.188	0.309	0.177	0.266	0.189	0.282	0.452	0.189	0.258	0.162	0.306	0.202	0.362
18	0.267	0.261	0.198	0.217	0.149	0.005	0.177	0.234	0.253	0.229	0.049	0.124	0.155	0.199	0.333	0.186	0.247	0.262	0.087	0.305	0.381	-0.123	0.299	0.149	0.208	0.100	0.229
19	0.409	0.291	0.273	0.357	0.230	0.154	0.262	0.277	0.361	0.200	0.282	0.362	0.168	0.321	0.060	0.668	0.349	0.258	0.218	0.258	0.538	0.038	0.310	0.101	0.317	0.215	0.366
20	0.132	-0.005	-0.112	0.123	0.050	0.141	0.050	0.167	0.224	0.058	0.150	0.026	0.008	0.201	0.053	0.180	0.263	0.039	0.153	0.147	0.121	-0.066	0.080	0.102	0.143	0.043	0.133
21	0.316	0.199	0.259	0.319	0.375	0.115	0.312	0.252	0.461	0.161	0.356	0.298	0.292	0.318	0.212	0.370	0.311	0.189	0.354	0.190	0.362	0.001	0.289	0.043	0.179	0.294	0.320
22	-0.036	0.090	0.116	0.101	-0.068	0.074	-0.111	0.121	-0.118	0.096	-0.134	-0.028	0.245	0.108	0.079	-0.856	-0.035	0.185	-0.851	0.186	0.078	0.164	0.002	0.128	0.037	-0.039	0.072
23	0.452	0.290	0.264	0.551	0.353	0.141	0.255	0.344	0.412	0.218	0.300	0.469	0.178	0.380	0.285	0.429	0.300	0.459	0.292	0.344	0.596	0.098	0.428	0.317	0.530	0.268	0.602
24	0.436	0.317	0.247	0.398	0.506	0.188	0.374	0.295	0.465	0.287	0.174	0.359	0.223	0.283	0.127	0.359	0.491	0.327	0.350	0.304	0.518	-0.032	0.567	0.200	0.343	0.203	0.488
25	0.261	0.262	0.174	0.176	0.402	0.126	0.332	0.188	0.443	0.125	0.221	0.232	0.144	0.235	-0.098	0.257	0.385	0.137	0.370	0.126	0.227	-0.053	0.295	0.052	0.116	0.259	0.167
26	0.279	0.448	0.189	0.244	0.402	0.104	0.277	0.228	0.380	0.255	0.002	0.277	0.204	0.272	0.089	0.301	0.299	0.260	0.262	0.224	0.443	0.028	0.438	0.233	0.213	0.192	0.315
27	-0.044	0.047	0.148	0.071	0.029	0.016	-0.116	0.186	-0.097	0.118	0.042	-0.042	0.167	0.032	0.055	-0.132	-0.049	0.084	-0.002	0.066	-0.055	0.246	0.032	0.074	0.194	-0.057	0.075
28	-0.055	0.078	0.068	0.062	0.060	0.072	0.081	0.114	0.060	-0.015	-0.010	0.246	-0.055	0.141	0.143	0.061	0.061	0.107	-0.078	-0.630	0.081	0.011	0.051	-0.971	0.108	0.024	0.049
29	0.433	0.277	0.295	0.532	0.352	0.162	0.254	0.378	0.475	0.297	0.266	0.483	0.183	0.442	0.232	0.463	0.394	0.547	0.249	0.407	0.599	0.048	0.527	0.284	0.483	0.308	0.588
30	0.469	0.340	0.261	0.448	0.404	0.080	0.321	0.248	0.503	0.341	0.139	0.433	0.211	0.436	0.231	0.412	0.476	0.437	0.332	0.336	0.598	0.049	0.576	0.332	0.344	0.278	0.493
31	0.107	0.103	0.207	0.320	0.275	0.217	0.221	0.214	0.153	0.064	0.121	0.174	0.202	0.336	0.014	0.171	0.247	0.227	0.140	0.211	0.187	0.021	0.123	0.118	0.163	0.251	0.238
32	-0.092	0.012	-0.039	0.051	-0.089	-0.046	0.072	0.165	-0.054	0.063	-0.019	0.016	0.132	0.062	0.022	-0.028	-0.038	-0.043	-0.089	0.039	-0.032	0.138	0.017	0.123	0.040	0.159	0.040
33	0.447	0.313	0.255	0.391	0.293	0.150	0.272	0.233	0.485	0.300	0.301	0.470	0.213	0.412	0.165	0.443	0.432	0.416	0.391	0.366	0.498	0.056	0.401	0.280	0.375	0.263	0.464
34	0.192	0.047	0.125	0.316	0.173	-0.010	0.298	0.450	0.280	0.300	0.151	0.307	0.311	0.244	0.256	0.085	0.281	0.184	0.144	0.346	0.407	0.109	0.340	0.234	0.247	0.158	0.275
35	0.241	0.176	0.101	0.280	0.263	0.096	0.281	0.284	0.326	0.038	0.353	0.316	0.130	0.255	0.043	0.245	0.166	0.118	0.205	0.213	0.317	-0.089	0.254	0.186	0.248	0.285	0.359
36	0.425	0.343	0.308	0.261	0.564	0.028	0.332	0.224	0.520	0.228	0.155	0.269	0.196	0.366	0.169	0.367	0.442	0.385	0.406	0.298	0.474	-0.061	0.614	0.278	0.314	0.226	0.396
37	1.000	0.306	0.274	0.379	0.292	0.009	0.342	0.270	0.439	0.256	0.123	0.364	0.064	0.375	0.225	0.418	0.361	0.438	0.314	0.227	0.681	-0.045	0.475	0.257	0.353	0.241	0.420
38	0.306	1.000	0.235	0.244	0.265	0.156	0.274	0.204	0.232	0.106	0.049	0.312	0.218	0.293	0.181	0.298	0.308	0.297	0.264	0.264	0.394	-0.045	0.336	0.158	0.164	0.143	0.270
39	0.274	0.235	1.000	0.313	0.213	0.049	0.241	0.195	0.209	0.153	0.125	0.191	0.223	0.156	0.073	0.278	0.220	0.311	0.275	0.258	0.282	0.147	0.240	0.121	0.225	0.240	0.223
40	0.379	0.244	0.313	1.000	0.214	0.173	0.286	0.474	0.364	0.295	0.179	0.355	0.278	0.536	0.173	0.286	0.215	0.429	0.262	0.394	0.546	0.132	0.369	0.232	0.460	0.301	0.533
41	0.299	0.265	0.213	0.214	1.000	0.123	0.310	0.164	0.435	0.203	0.313	0.274	0.201	0.189	0.153	0.320	0.369	0.268	0.344	0.271	0.421	-0.043	0.466	0.190	0.226	0.254	0.409
42	0.099	0.156	0.049	0.173	0.123	1.000	0.004	0.068	0.103	-0.065	0.124	0.091	0.123	0.188	-0.120	0.118	0.181	0.138	0.084	0.195	0.116	0.064	0.061	0.030	0.108	0.119	0.181
43	0.342	0.276	0.241	0.266	0.310	0.004	1.000	0.242	0.328	0.203	0.061	0.192	0.321	0.199	0.047	0.318	0.360	0.226	0.238	0.239	0.389	-0.075	0.329	0.177	0.091	0.460	0.130
44	0.270	0.204	0.195	0.474	0.164	0.068	0.242	1.000	0.249	0.225	0.231	0.407	0.316	0.408	0.181	0.260	0.112	0.190	0.230	0.268	0.411	0.255	0.283	0.117	0.318	0.236	0.309
45	0.439	0.232	0.209	0.364	0.435	0.103	0.328	0.249	1.000	0.200	0.258	0.400	0.148	0.348	0.124	0.389	0.474	0.328	0.440	0.256	0.484	-0.063	0.484	0.214	0.246	0.315	0.441
46	0.258	0.166	0.153	0.295	0.203	-0.068	0.203	0.225	0.200	1.000	0.191	0.307	0.303	0.333	0.200	0.241	0.285	0.290	0.110	0.263	0.359	0.056	0.317	0.440	0.170	0.149	0.244
47	0.123	0.049	0.125	0.179	0.313	0.124	0.061	0.231	0.258	0.191	1.000	0.329	0.082	0.236	0.072	0.285	0.173	0.050	0.279	0.200	0.244	-0.005	0.173	0.116	0.240	0.133	0.274
48	0.364	0.312	0.191	0.355	0.274	0.091	0.192	0.467	0.400	0.207	0.329	1.000	0.180	0.326	0.247	0.393	0.259	0.353	0.278	0.278	0.497	0.105	0.418	0.274	0.480	0.167	0.515
49	0.064	0.218	0.223	0.278	0.201	0.123	0.321	0.316	0.148	0.303	0.084	0.180	1.000	0.217	0.147	0.139	0.157	0.163	0.087	0.448	0.274	0.105	0.148	0.131	0.064	0.187	0.112
50	0.378	0.293	0.156	0.536	0.180	0.188	0.199	0.408	0.348	0.333	0.236	0.326	0.217	1.000	0.151	0.371	0.310	0.418	0.269	0.330	0.510	0.097	0.299	0.344	0.378	0.331	0.401
51	0.225	0.181	0.073	0.173	0.153	-0.120	0.047	0.181	0.124	0.200	0.072	0.247	0.147	0.151	1.000	0.215	0.171	0.243	0.118	0.216	0.359	-0.027	0.349	0.162	0.348	0.017	0.264
52	0.418	0.298	0.278	0.266	0.320	0.118	0.318	0.260	0.380	0.241	0.283	0.393	0.139	0.371	0.215	1.000	0.446	0.248	0.338	0.298	0.544	0.067	0.446	0.242	0.287	0.099	0.371
53	0.361	0.308	0.220	0.215	0.369	0.181	0.360	0.112	0.474	0.285	0.113	0.259	0.157	0.310	0.171	0.446	1.000	0.361	0.342	0.287	0.420	-0.065	0.422	0.324	0.211	0.201	0.364
54	0.438	0.297	0.311	0.429	0.268	0.135	0.226	0.198	0.328	0.298	0.050	0.353	0.163	0.408	0.213	0.248	0.361	1.000	0.269	0.282	0.483	0.009	0.444	0.426	0.430	0.360	0.494
55	0.314	0.204	0.279	0.262	0.344	0.095	0.235	0.233	0.444	0.110	0.279	0.383	0.087	0.289	0.118	0.338	0.342	0.269	1.000	0.294	0.288	0.105	0.348	0.208	0.322	0.227	0.371
56	0.227	0.264	0.258	0.394	0.271	0.195	0.239	0.268	0.256	0.263	0.204	0.278	0.448	0.330	0.216	0.298	0.287	0.282	0.294	1.000	0.436	0.123	0.320	0.311	0.289	0.268	0.348
57	0.441	0.394	0.282	0.546	0.421	0.116	0.389	0.411	0.484	0.339	0.244	0.497	0.274	0.510	0.359	0.544	0.420	0.483	0.288	0.436	1.000	-0.002	0.621	0.363	0.465	0.232	0.546
58	-0.048	-0.045	-0.147	-0.132	-0.043	0.064	-0.075	0.255	-0.063	0.056	-0.005	0.105	0.105	0.097	-0.027	0.097	-0.065	0.009	0.105	0.123	-0.002	1.000	0.027	0.102	0.207	-0.005	0.090
59	0.475	0.338	0.240	0.369	0.466	0.061	0.329	0.283	0.482	0.317	0.173	0.418	0.148	0.299	0.349	0.446	0.422	0.444	0.348	0.320	0.621	0.027	1.000	0.333	0.449	0.254	0.503
60	0.257	0.158	0.121	0.232	0.190	0.030	0.177	0.112	0.214	0.440	0.118	0.274	0.131	0.346	0.142	0.242	0.324	0.426	0.268	0.311	0.363	0.102	0.333	1.000	0.345	0.244	0.307
61	0.353	0.164	0.225	0.400	0.226	0.108	0.091	0.318	0.246	0.170	0.240	0.468	0.064	0.370	0.348	0.287	0.211	0.430	0.322	0.289	0.465	0.207	0.449	0.345	1.000	0.234	0.530
62	0.241	0.143	0.240	0.301	0.254	0.115	0.460	0.236	0.315	0.149	0.133	0.167	0.187	0.331	0.017	0.099	0.201	0.360	0.227	0.265	0.232	-0.005	0.254	0.244	0.234	1.000	0.280
63	0.420	0.270	0.223	0.533	0.409	0.181	0.130	0.309	0.441	0.244	0.274	0.515	0.112	0.401	0.264	0.371	0.364	0.494	0.371	0.348	0.546	0.090	0.504	0.307	0.530	0.280	1.000

FACTOR ANALYSIS

The correlation between the 63 variables was now factor analysed by the "principal component" method. As a further filtration to ensure extraction of the significant factors, the factors were rotated about their axes orthogonally. This attained a simple structure that yields greater meaningfulness. This "principal component" orthogonal solution is well documented[17] and has yielded significant results for many researches both at Manchester and elsewhere. Included below are the rotated factors for all data, for all printers and for all engineers. The significant variables in each factor for all data are underlined.

---

17. H.F.Kaiser. "The Application of Electronic Computers in Psychological Problems". Annual Meeting of the American Psychological Assoc. Cincinatti, 1959.

ROTATED FACTORS — ALL DATA

	JOB RELATION FACTOR	LEARNING FACTOR							
1	0.749	0.140	-0.020	-0.044	-0.082	-0.048	0.000	-0.041	0.034
2	0.172	0.591	-0.012	0.325	0.002	-0.021	0.001	0.086	0.001
3	0.650	0.328	-0.099	0.074	0.005	-0.144	0.041	0.052	-0.022
4	-0.093	0.260	0.074	0.033	0.017	-0.047	-0.097	-0.015	0.071
5	-0.176	0.103	-0.126	0.103	0.199	0.053	0.175	0.482	0.242
6	0.116	0.133	-0.023	0.720	0.086	0.048	-0.038	0.027	0.060
7	-0.585	0.050	0.074	-0.042	-0.005	-0.075	0.104	0.009	-0.031
8	-0.012	0.140	-0.067	-0.020	0.092	-0.788	-0.040	0.030	0.070
9	-0.215	0.076	-0.001	0.147	0.098	-0.065	-0.078	0.075	0.066
10	-0.631	0.203	-0.053	0.053	-0.088	0.114	-0.180	0.030	0.050
11	-0.263	0.551	0.058	0.066	0.132	0.035	0.010	-0.049	0.000
12	-0.223	0.125	-0.046	-0.068	0.053	0.019	-0.032	-0.010	0.140
13	-0.161	0.667	-0.038	0.040	-0.004	0.201	0.046	-0.037	0.343
14	0.020	0.094	0.008	0.087	0.802	-0.053	0.131	0.043	-0.027
15	-0.110	0.616	-0.042	-0.051	0.115	0.001	-0.051	-0.043	-0.251
16	-0.326	0.479	0.152	0.178	-0.028	-0.055	0.063	0.156	0.006
17	-0.150	0.223	0.032	0.207	0.029	0.016	-0.167	0.077	0.172
18	-0.190	0.190	-0.128	0.590	0.129	-0.150	0.063	0.067	-0.010
19	-0.201	0.315	-0.082	0.051	-0.090	-0.028	-0.044	0.010	0.005
20	-0.074	0.011	0.110	-0.029	-0.015	-0.032	-0.801	0.051	0.014
21	-0.351	0.081	-0.008	0.206	0.061	-0.131	-0.007	-0.097	0.074
22	0.013	-0.005	0.232	0.343	-0.113	-0.203	0.372	0.154	-0.238
23	-0.259	0.601	-0.086	0.035	0.022	-0.182	0.012	0.102	0.071
24	-0.692	0.253	-0.102	0.145	0.111	0.152	-0.026	0.088	0.030
25	-0.569	-0.063	-0.129	-0.074	0.001	0.150	0.012	-0.051	-0.074
26	-0.562	0.149	-0.075	-0.144	-0.010	0.051	0.208	0.049	-0.051
27	0.014	0.028	0.002	0.101	0.764	-0.078	-0.180	0.026	0.042
28	0.004	0.058	0.034	-0.011	0.025	-0.100	-0.018	-0.068	0.812
29	-0.335	0.559	0.028	0.078	0.122	-0.106	-0.148	0.138	0.122
30	-0.594	0.402	-0.018	0.119	-0.025	0.032	0.018	0.202	-0.094
31	-0.171	0.063	0.351	0.073	0.155	-0.077	-0.337	0.040	0.321
32	0.145	-0.088	-0.026	-0.040	0.075	0.304	0.140	0.342	-0.186
33	-0.341	0.389	0.091	0.184	0.041	-0.115	-0.025	0.143	-0.069
34	-0.269	0.219	-0.150	0.414	0.097	0.341	-0.170	0.206	0.174
35	-0.133	0.385	-0.055	0.046	0.009	-0.006	-0.336	-0.153	-0.033
36	-0.774	0.213	-0.067	0.025	0.126	-0.074	-0.114	0.061	0.010
37	-0.307	0.518	-0.236	0.081	-0.043	-0.129	-0.080	0.018	-0.196
38	-0.266	0.181	0.109	0.169	-0.021	-0.299	0.091	-0.071	-0.019
39	-0.205	0.176	-0.013	0.177	0.157	-0.276	0.194	-0.092	0.036
40	-0.158	0.523	0.124	0.227	0.110	-0.031	0.015	0.043	-0.041
41	-0.642	0.137	0.117	0.003	0.069	-0.137	-0.003	0.067	0.120
42	-0.052	0.141	0.798	0.087	-0.033	0.027	-0.107	-0.049	0.033
43	-0.271	0.103	-0.127	0.249	-0.134	0.062	-0.064	0.055	0.065
44	-0.128	0.250	-0.129	0.279	0.068	0.136	-0.087	-0.073	0.066
45	-0.584	0.305	-0.038	0.059	-0.091	-0.044	-0.101	-0.038	-0.048
46	-0.198	0.095	-0.133	0.308	0.116	0.011	-0.034	0.605	-0.032
47	-0.144	0.146	0.049	0.011	0.089	-0.000	-0.141	0.080	-0.022
48	-0.213	0.564	-0.061	0.076	-0.153	0.103	0.122	0.059	0.304
49	-0.115	-0.006	0.153	0.736	0.049	0.075	0.079	0.056	-0.034
50	-0.150	0.274	0.113	0.125	-0.073	-0.132	-0.11	0.303	-0.019
51	-0.099	0.240	-0.369	0.301	-0.002	-0.348	-0.051	0.230	0.229
52	-0.294	0.273	-0.025	0.036	-0.160	-0.176	-0.109	0.120	0.022
53	-0.496	0.126	0.149	0.131	-0.081	-0.122	-0.265	0.288	0.032
54	-0.250	0.490	0.132	0.057	-0.005	-0.324	0.076	0.316	0.044
55	-0.420	0.248	-0.098	0.046	-0.160	-0.091	-0.176	-0.015	-0.167
56	-0.195	0.299	0.190	0.507	-0.098	-0.104	-0.184	0.190	-0.057
57	-0.377	0.604	-0.073	0.264	-0.064	-0.087	-0.040	0.108	-0.008
58	0.067	0.065	-0.000	0.002	0.069	0.188	0.074	0.081	-0.008
59	-0.607	0.449	-0.146	0.083	-0.016	-0.024	-0.055	0.174	0.016
60	-0.133	0.328	0.013	0.050	-0.045	-0.057	-0.114	0.694	-0.132
61	-0.100	0.632	-0.035	-0.003	0.113	-0.068	-0.093	0.233	0.134
62	-0.100	0.202	0.068	0.005	-0.109	-0.077	0.023	0.192	-0.028
63	-0.299	0.699	0.142	0.021	0.045	-0.111	-0.002	0.138	0.009

ROTATED FACTORS — PRINTERS

1	-0.776	-0.059	-0.003	-0.065	-0.092	-0.192	-0.042	0.104	-0.004
2	-0.117	-0.511	0.067	0.267	0.310	0.127	-0.093	0.003	0.019
3	-0.622	-0.181	0.150	-0.143	0.118	-0.029	-0.054	-0.048	-0.139
4	-0.175	-0.469	-0.240	-0.014	0.058	-0.032	-0.106	0.218	-0.023
5	-0.094	-0.095	0.026	0.047	-0.001	0.034	-0.154	-0.073	-0.075
6	0.117	-0.147	-0.059	0.696	-0.092	0.057	-0.048	0.022	0.028
7	-0.718	-0.075	-0.065	-0.091	0.085	0.037	0.169	0.173	-0.120
8	-0.009	-0.031	-0.068	-0.046	0.738	0.000	-0.167	0.074	0.096
9	-0.191	-0.070	-0.146	0.054	0.075	-0.047	-0.085	0.018	-0.060
10	-0.616	-0.213	-0.116	0.146	-0.046	0.187	0.056	0.083	-0.037
11	-0.137	-0.588	-0.076	0.036	-0.017	0.035	0.049	-0.138	-0.256
12	-0.199	-0.115	-0.057	-0.043	0.066	0.056	-0.041	0.040	-0.055
13	-0.244	-0.719	0.057	0.098	0.046	0.129	0.051	-0.132	-0.026
14	0.027	-0.055	0.017	-0.037	0.117	-0.057	-0.010	-0.029	-0.157
15	-0.062	-0.150	0.031	0.038	-0.108	0.031	-0.108	0.097	-0.833
16	-0.265	-0.559	-0.064	0.101	0.114	-0.051	-0.176	-0.032	-0.268
17	-0.078	-0.406	-0.610	0.193	-0.101	-0.226	-0.078	-0.098	-0.026
18	-0.031	-0.232	0.020	0.465	0.346	-0.099	-0.076	-0.210	0.040
19	-0.255	-0.371	-0.051	0.093	0.057	0.065	0.149	-0.065	-0.438
20	-0.073	-0.018	-0.778	-0.036	-0.009	0.115	-0.014	0.156	-0.046
21	-0.375	-0.135	-0.208	0.153	-0.020	0.141	0.050	-0.042	-0.096
22	-0.018	-0.026	0.086	0.312	-0.041	-0.616	-0.220	0.255	-0.095
23	-0.226	-0.677	-0.121	-0.025	0.064	0.045	-0.085	0.130	-0.009
24	-0.681	-0.343	0.039	0.201	-0.068	0.047	0.042	0.133	-0.004
25	-0.531	-0.106	-0.207	-0.080	-0.038	0.207	-0.001	0.055	0.206
26	-0.611	-0.199	-0.033	0.162	0.043	-0.126	-0.167	-0.133	-0.097
27	-0.016	-0.084	-0.169	0.281	-0.137	-0.098	-0.048	-0.015	0.147
28	-0.073	-0.119	-0.486	0.086	0.180	0.035	0.279	-0.081	0.005
29	-0.337	-0.565	-0.312	0.099	0.129	0.050	-0.149	0.086	-0.141
30	-0.582	-0.420	-0.122	0.042	0.021	-0.105	-0.269	-0.091	-0.008
31	-0.092	-0.194	-0.547	0.021	-0.070	0.128	0.072	0.295	0.190
32	0.155	-0.073	-0.042	-0.041	-0.031	0.044	-0.077	-0.047	0.004
33	-0.432	-0.354	-0.129	0.242	0.224	-0.027	-0.290	0.041	0.105
34	-0.230	-0.311	-0.300	0.394	-0.246	0.067	-0.084	-0.376	-0.093
35	-0.175	-0.294	-0.324	0.097	0.124	0.360	-0.034	-0.127	-0.143
36	-0.720	-0.227	-0.159	0.030	0.072	0.078	-0.099	-0.125	0.060
37	-0.268	-0.425	0.052	0.002	0.099	0.254	-0.117	-0.039	-0.158
38	-0.281	-0.187	0.018	0.297	0.557	-0.044	0.013	-0.038	0.010
39	-0.177	-0.128	0.049	0.106	0.111	0.113	-0.100	-0.068	0.016
40	-0.075	-0.619	-0.177	0.148	-0.078	0.074	-0.066	0.185	-0.172
41	-0.532	-0.185	-0.072	0.036	-0.058	0.139	0.031	0.146	0.115
42	-0.068	-0.085	-0.176	0.130	0.009	-0.117	0.088	0.775	-0.086
43	-0.220	-0.098	-0.014	0.239	0.093	0.691	-0.055	-0.056	-0.124
44	-0.149	-0.511	-0.224	0.279	-0.200	-0.082	0.087	-0.133	0.050
45	-0.636	-0.233	-0.197	0.013	0.176	0.208	-0.139	-0.052	-0.102
46	-0.167	-0.072	0.029	0.295	-0.057	0.039	-0.638	-0.206	-0.024
47	-0.052	-0.196	-0.079	-0.024	0.010	0.137	-0.049	0.009	0.093
48	-0.335	-0.685	0.081	0.147	0.085	0.029	0.013	-0.121	0.028
49	-0.122	-0.112	-0.019	0.701	-0.069	0.000	-0.055	0.030	-0.137
50	-0.132	-0.529	-0.394	0.116	0.117	-0.018	-0.282	0.063	0.044
51	-0.076	-0.221	-0.042	0.120	0.154	-0.090	-0.013	-0.220	-0.086
52	-0.293	-0.279	-0.028	-0.003	0.200	-0.030	0.003	-0.078	-0.361
53	-0.430	-0.077	-0.149	0.036	0.170	0.121	-0.159	0.043	-0.066
54	-0.201	-0.461	-0.046	0.033	0.129	-0.006	-0.420	0.196	-0.034
55	-0.336	-0.273	-0.106	0.141	-0.003	0.143	-0.055	-0.016	0.112
56	-0.105	-0.224	-0.054	0.633	0.112	0.073	-0.125	0.297	-0.066
57	-0.354	-0.646	-0.058	0.166	0.107	0.082	-0.107	-0.041	-0.296
58	-0.021	-0.079	-0.025	0.202	-0.569	-0.258	-0.190	0.001	-0.063
59	-0.648	-0.391	0.043	0.064	-0.007	0.139	-0.191	-0.035	-0.077
60	-0.076	-0.264	0.060	0.014	0.048	-0.016	-0.805	0.007	-0.075
61	-0.160	-0.747	-0.052	-0.009	-0.025	0.042	-0.148	-0.003	0.123
62	-0.103	-0.250	-0.124	0.043	0.014	0.500	-0.280	0.268	0.084
63	-0.219	-0.716	-0.017	0.103	-0.030	-0.062	-0.094	0.086	-0.009

ROTATED FACTORS — ENGINEERS

1	0.446	0.033	-0.569	0.017	0.010	0.004	0.105	0.180	-0.013
2	0.729	0.191	-0.152	-0.125	0.085	0.108	-0.029	-0.073	0.112
3	-0.515	0.070	-0.529	-0.021	0.097	0.049	-0.120	0.088	0.058
4	0.166	0.578	0.088	0.031	-0.122	0.225	-0.044	0.033	-0.383
5	0.184	0.320	-0.155	0.189	0.351	0.170	-0.390	0.268	-0.283
6	0.109	0.206	0.168	0.035	0.067	0.022	-0.055	0.093	-0.097
7	0.164	0.072	-0.312	0.083	0.069	0.025	-0.086	-0.013	-0.492
8	0.277	-0.248	-0.010	0.055	-0.337	0.082	-0.098	0.137	-0.190
9	0.107	-0.060	-0.173	-0.021	-0.001	-0.124	-0.007	-0.118	-0.042
10	0.224	0.140	-0.610	0.140	0.186	0.077	0.060	-0.003	-0.321
11	0.773	0.132	-0.320	0.076	0.007	0.149	-0.081	-0.165	-0.117
12	0.201	0.010	-0.169	-0.034	-0.119	-0.005	0.032	0.105	-0.115
13	0.573	0.194	-0.133	-0.260	0.084	-0.082	-0.014	0.289	0.043
14	0.074	0.183	-0.057	0.046	-0.014	0.060	-0.813	0.047	-0.072
15	0.730	-0.017	-0.090	-0.123	-0.020	-0.174	-0.099	-0.057	-0.195
16	0.313	0.122	-0.393	0.108	0.242	-0.095	0.013	0.110	-0.514
17	0.289	0.663	-0.131	0.068	0.079	-0.118	-0.052	0.236	-0.309
18	0.199	0.196	-0.363	0.209	0.070	0.372	-0.167	-0.136	0.017
19	0.367	0.092	-0.156	-0.026	0.014	-0.089	0.062	-0.024	-0.717
20	0.180	0.119	0.088	-0.644	0.268	0.105	0.044	-0.168	-0.184
21	0.196	0.159	-0.260	-0.101	-0.274	0.183	-0.095	0.158	-0.176
22	0.034	0.053	0.112	0.746	0.062	-0.110	0.030	-0.100	-0.089
23	0.715	0.118	-0.129	0.088	0.077	-0.143	-0.045	0.181	-0.245
24	0.328	0.068	-0.669	-0.089	0.027	-0.019	-0.080	0.082	-0.065
25	0.025	0.132	-0.727	0.063	-0.141	-0.007	0.018	-0.153	-0.077
26	0.199	0.037	-0.562	0.108	0.014	0.038	0.133	0.041	-0.017
27	0.002	-0.122	0.062	-0.063	0.008	-0.212	-0.827	-0.056	0.121
28	0.032	0.043	0.045	-0.032	-0.010	-0.013	0.021	0.906	-0.003
29	0.603	0.195	-0.210	-0.038	-0.035	-0.138	-0.035	0.143	-0.229
30	0.488	0.174	-0.498	-0.031	0.048	-0.009	-0.095	0.134	-0.307
31	0.072	0.077	-0.123	-0.324	0.234	-0.083	-0.208	0.239	-0.256
32	0.060	0.519	0.005	0.496	0.311	-0.144	0.062	-0.094	0.030
33	0.490	0.021	-0.178	-0.026	-0.043	0.016	-0.092	-0.159	-0.469
34	0.131	0.420	-0.181	0.220	0.549	0.048	-0.227	0.065	0.070
35	0.244	0.189	-0.196	-0.267	0.034	0.077	0.092	-0.008	0.025
36	0.365	-0.095	-0.744	-0.069	0.149	0.009	-0.169	-0.049	-0.131
37	0.740	0.001	-0.189	-0.073	0.041	0.059	0.024	-0.148	-0.241
38	0.233	0.058	-0.460	0.027	-0.115	-0.158	-0.045	-0.010	-0.091
39	0.282	-0.113	-0.218	0.183	-0.146	-0.526	-0.179	0.043	-0.189
40	0.574	0.311	-0.141	0.107	-0.025	-0.154	-0.164	-0.032	-0.036
41	0.299	-0.093	-0.669	0.054	0.036	0.145	-0.050	0.038	-0.042
42	0.070	0.026	-0.084	-0.057	0.048	-0.001	-0.032	0.044	-0.131
43	0.183	0.160	-0.388	-0.067	0.076	-0.086	0.109	0.056	-0.062
44	0.186	0.789	-0.089	-0.070	0.007	-0.187	-0.064	0.006	0.031
45	0.425	0.202	-0.432	-0.093	0.002	0.172	0.114	-0.072	-0.149
46	0.289	0.004	-0.152	-0.040	0.208	-0.056	-0.190	0.108	-0.183
47	0.141	0.180	-0.224	-0.048	0.147	-0.038	-0.195	-0.061	-0.138
48	0.321	0.274	-0.228	-0.030	0.250	-0.143	0.174	0.325	-0.212
49	0.042	0.269	-0.171	0.148	0.083	0.052	-0.131	-0.159	-0.035
50	0.171	0.274	-0.106	-0.045	0.181	-0.030	-0.015	-0.033	-0.244
51	0.290	0.196	-0.001	0.065	0.053	0.032	-0.116	0.080	-0.040
52	0.422	0.142	-0.305	-0.228	0.092	-0.089	0.135	0.039	-0.559
53	0.222	0.068	-0.483	-0.173	0.322	0.007	0.125	-0.049	-0.253
54	0.544	-0.251	-0.164	0.200	0.079	0.136	0.072	0.032	-0.097
55	0.191	-0.091	-0.530	-0.197	0.222	-0.282	0.009	-0.293	-0.094
56	0.368	0.210	-0.260	-0.019	0.285	-0.206	0.098	-0.319	-0.142
57	0.672	0.224	-0.300	0.007	0.119	0.037	0.095	-0.040	-0.198
58	0.015	0.159	0.060	0.133	0.039	-0.814	-0.092	-0.005	-0.017
59	0.576	0.088	-0.470	-0.027	0.213	-0.101	-0.003	-0.001	-0.035
60	0.246	-0.032	-0.129	-0.073	0.762	-0.034	0.044	-0.035	-0.105
61	0.423	-0.094	0.007	0.139	0.264	-0.322	-0.086	0.045	-0.201
62	0.127	0.064	-0.118	0.140	0.127	0.049	0.067	0.048	-0.084
63	0.748	-0.053	-0.240	0.035	0.123	0.090	-0.103	0.088	-0.135

It will be seen that the ~~through~~ three analyses showed relatively similar variables forming the main factors, and I therefore decided to take the factors shown by the analysis of All Data, as the two factors for all further analysis.

Factor 1 - Explained 38.438% of all variance, and

Factor 2 - Explained 7.926% of all variance. *

A total of 46.364%. All other factors explained less than 6% each, and it was therefore felt that there could be no useful analysis of them.

JOB RELATION FACTOR

The first factor was made up of the following seven variables:

Variable	Factor Loading	Statement
36	.774	My use of information has been affected by participation.
1	.749	The game revealed a number of problem areas for me which I have subsequently pursued.
24	.692	After the time elapsed I can find areas of improvement in my management ability attributable to the game.

* EXPLAINED VARIANCE

	ENGINEERS	PRINTERS
FACTOR 1.	37.129 %.	33.367 %.
FACTOR 2.	7.541 %.	7.944 %.

Variable	Factor Loading	Statement
3	.650	There has been a change in my approach to management problems.
41	.642	There has been a positive change in my ability to take logical decisions.
10	.631	Experience of the game has taught me to pay more attention to correcting the consequences of faulty decisions in my normal work.
59	.607	The lessons of the game offered me help in solving day-to-day problems.

It will be noted that each of these statements related to the actual job held by the respondent. I therefore called this factor, the Job Relation Factor. It should be noted that the factor loadings are all greater than .600 which is extremely high. As would be expected by the nature of factor analysis, the correlation among these seven factors is extremely high. There are, in fact, 10 internal correlations among the seven items greater than +0.500. Below I will examine each of the variable statements in this first factor more closely.

36 - My use of information has been affected by participation.

Mean	Engineers	3.373
	Printers	3.092

The games threw up more information than could be usefully analysed or assimilated by any individual team member in the 20 minutes decision period. It therefore was a critical criteria of success to be able to screen information, and use only that necessary within the framework of your team function. The Engineers are significantly higher which is probably due to their much longer exposure to the exercise.

1 - The game revealed a number of problem areas for me which I have subsequently pursued.

Mean	Engineers	3.027
	Printers	2.933
Standard Deviation	Engineers	1.039
	Printers	0.972

The means taken in conjunction with their dispersion indicated that ~~some 40%~~ 41.2% (by cell count) of the participants felt that

the game revealed problem areas to them. The key idea in this statement seems to be revelation. I feel that this figure is extremely important because a valid answer to this statement means that we have made the respondent think in a new area.

24 - After the time elapsed I can find areas of improvement in my management ability attributable to the game.

Mean Engineers 3.440

Printers 3.076

Both groups gave a mean positive response to this statement about changes in their actual job ability after an average of 10 months.

3 - There has been a change in my approach to management problems.

Mean Engineers 3.220

Printers 2.983

Method of approach to problems is one of the areas that I always dealt with during debriefing in the middle of the exercise. It is interesting to note that this has a +0.488 correlation with statement 36 on the use of

information. I always stressed these two items together in debriefing.

44 - There has been a positive change in my ability to take logical decisions.

Mean Engineers 2.787

Printers 2.748

This item shows an even stronger correlation with item 36 on the use of information, +0.564.

10 - Experience of the game has taught me to pay more attention to correcting the consequences of faulty decisions in my normal work.

Mean Engineers 3.147

Printers 3.134

Because of the pressure of work during the game, some faulty decisions are generally taken. This is in line with one of Skinner's concepts of learning:

> "If a man has error-free learning he cannot handle a new situation because he does not understand the logic of it".

Because of the fact that these faulty decisions are made,

and that they become painfully obvious in a very short time, the need to correct them is strongly reinforced. It is not surprising, therefore, that this item correlates very strongly with item 1 +0.523, item 24 +0.537, item 36 +0.511, and with item 30 - the game gave me additional insight into my process of decision taking +0.510.
59 - The lessons of the game afforded me help in solving day-to-day problems.

Mean	Engineers	3.293
	Printers	3.176

As a teacher I am most pleased with this result because, in fact, this is one of the key aims of any management development programme.

LEARNING FACTOR

The second factor was made up of the following seven variables.

Variable	Factor Loading	Statement
63	.699	I would recommend my fellow managers to participate in a similar exercise.

Variable	Factor Loading	Statement
13	.677	I have had some benefit from participating in this business game and feel there is need to repeat the exercise.
61	.632	Games are a practical method of management training.
15	.616	The game was as useful for the group with which it was used as it would be for training people coming into the industry.
57	.604	A two day course of lectures on a management subject would not have been of greater value.
23	.601	Playing games is not a waste of time.
2	.591	I would have gained less participating in a case study.

It will be noted that each of these statements related to the learning value or usefulness of the game to the respondent without specific reference altogether to his job. I therefore called this factor the Learning Factor. It should also be noted that the factor loadings are greater than .591 which is extremely high. Again the internal correlation among the variances within this factor yields 9 greater than ~~5.00~~ 0.50. Below I will examine each of the variable statements in the second factor more closely.

63 - I would recommend my fellow managers to participate in a similar exercise.

Mean Engineers 3.973

Printers 4.118

The fact that a manager would recommend his fellows to similar exercises is probably their greatest single commendation of their feeling of the value of the exercise. The mean score for this item for Engineers Group 2 was +3.200 which clearly brought down their group mean; taking Engineers groups 1, 3 and 4 only, the group mean becomes 4.255. It will, therefore, be seen how strong the universe feeling towards the exercise was.

13 - I have had some benefit from participating in this business game and feel there is need to repeat the exercise.

Mean Engineers +2.787

Printers +3.420

~~This~~ The result for printers is clearly due to the fact that the participants all felt in their final debriefing session that they would have done better given more time to acclimatise

themselves to an exercise. I felt these figures really indicated the need for game play to exceed 4 hours.

61 - Games are a practical method of management training.

Mean	Engineers	+3.947
	Printers	+4.042

This is again a general evaluation of the exercise with a very strong positive result.

15 - The game was as useful for the group with which it was used as it would have been for training people coming into the industry.

Mean	Engineers	3.880	
	Printers	3.992	Standard Deviation 0.604

Outside of statement 4 which is a very high mean, this statement achieved the least dispersion of opinion among the printers. There was a very strong feeling that the exercise, although simple, was most appropriate for the higher levels, as they felt that it dealt with the total company policy integration.

57 - A two day course (one day for printers) of lectures on a management subject would not have been of greater

value.

Mean Engineers +3.467

Printers +3.429

The answer from the engineers is particularly significant because of the large training programme which is mounted annually by the Engineering Employers West of England Association. It is very extensive and covers most areas of management thought. The majority of the participants in the engineering groups have participated in other training programmes with the Association.

23 - Playing the game is not a waste of time.

Mean Engineers 4.307

Printers 4.286

To achieve figures in this order we must surely be getting the strongest possible concensus of opinion.

2 - I would have gained less participating in a case study.

Mean Engineers 3.240

Printers 3.134

Again the opinion of the Engineers is most important, as to my knowledge, a majority of them have participated in case

studies, and are, therefore, relating first hand experience. I was also told that this is true of the printers.

ANALYSIS OF VARIANCE

We now have two factors of seven variables ~~each~~ between them which explained 45% of the total variance. In simple terms, this means that we have two groups of items about which 219 managers, dispersed over all of England, have replied extremely consistently. This does not mean that they have given the same reply, but does mean that the pattern of response of each individual, whether positive or negative, has remained consistent within these two item groups. The high consistency of this response will be demonstrated by the analysis of variance of all engineers.

ANALYSIS OF VARIANCE - ALL ENGINEERS

GROUP	1				2				3				4			
Source of Variation	Sum of the Squares	Degree of Freedom	Est. of Var.	F (Sig)	S^2	^oF	Est. of Var.	F (Sig)	S^2	^oF	Est. of Var.	F (Sig)	S^2	^oF	Est. of Var.	F (Sig)
LEARNING FACTOR																
ITEMS	36	6	6.0	7.78 (.001)	54.4	6	9.07	16.6 (.001)	32.2	6	5.37	11.67 (.001)	19.4	6	3.23	8.50 (.001)
MEN	62.6	18	3.47	4.51 (.001)	88.8	19	4.67	8.57 (.001)	30.4	18	1.69	3.67 (.001)	20	16	1.25	3.29 (.001)
RESIDUAL	83.3	108	0.771		62.2	114	0.545		49.8	108	0.461		36.6	96	0.381	
JOB RELATION FACTOR																
ITEMS	7.6	6	1.27	2.15 (.06)	5.0	6	0.83	1.34 (ns)	4.6	6	0.88	2.39 (.04)	9.3	6	1.55	3.37 (.007
MEN	57.6	18	3.2	5.42 (.001)	88.7	19	4.67	7.56 (.001)	52.9	18	2.94	7.99 (.001)	35.6	16	2.19	4.76 (.001
RESIDUAL	63.6	108	0.589		70.4	114	0.618		39.7	108	.368		44.1	96	0.459	
CONTROL SET																
ITEMS	10	6	1.67	2.14 (ns)	12.0	6	2.0	2.32 5%	9.3	6	1.55	1.58	10.8	6	1.8	2.05 (ns)
MEN	22.1	18	1.23	1.58 (ns)	37.3	19	1.96	2.27 1%	12.3	18	0.68	.69	24.3	16	1.52	1.73 (ns)
RESIDUAL	84.6	108	0.78		98.3	114	0.862		105.6	108	0.98	(ns)	84.6	96	0.88	

The "F" value for variation between men is significant beyond .001 in every case. This clearly shows that;

a. there has been no collusion, and

b. that we are measuring something within the person based on the result of the game.

To demonstrate the concordance in the data between engineers and printers, I have done an Analysis of Variance for Printers groups 1, 3 and 5 examining all fourteen factor variables simultaneously. The results all show significance beyond the 1/10 of 1% level.

ANALYSIS OF VARIANCE - PRINTERS

GROUP	1				3				5			
Souree of Variation	Sum of the Squares	Degree of Freedom	Estimate of Variance	F (Sig)	S^2	^oF	Est. of Var.	F (Sig)	S^2	^oF	Est. of Var.	F (Sig
ITEMS	188.8	13	14.52	28.25	87.1	13	6.70	11.0	55.1	13	4.24	8.0
MEN	89.1	25	3.56	6.93	47.6	14	3.40	5.58	66.5	14	4.75	9.0
RESIDUAL	167.1	325	0.514		110.9	182	0.609		96	182	0.528	

It might possibly be said that although there was this difference in men, it was accounted for by something which was inherent in the men, and not in their attitude towards the game. To check this, I selected a Control Set of totally unrelated items.

CONTROL SET

This included:

14. All participants appeared to be equally earnest.

22. Loss of profits and ruffled feelings can be attributed to fortuitous events.

27. The exercise did not appear to distress the older participants.

28. Its inclusion in a formal course of management training would have enhanced the value of the game.

31. The conduct of the game by the organisers aided its usefulness to me.

42. The fact that many problems in the game could have been solved by statistical analysis made the game more useful.

58. The exercise did not physically exhaust me.

The analysis of variance on these items is also shown on the main Engineers Variance Analysis Sheet.

Only two of these figures are in any way significant and one of those at the 5% level. I, therefore, feel justified in saying that the variance in the Control group could not be significantly attributed to either the men or the items, and was therefore residual. If that is the case, then I can restate my previous thesis for the two factors identified;

a. there has been no collusion, and

b. that we are measuring something within the person based on the result of the game.

The final item of proof of validity which is offered by these figures is their magnitude. The average "F" value for variance caused by differences between men for:

Learning Factor	5.01
Job Relation Factor	6.43
Control Set	1.57

Both the "L" and "J" factors are significant beyond the

.001 level while the Control Set is not significant. This means that the chance of this difference between men being shown in this way, by random action, is smaller than one chance in a 100,000. In other words, the variance shown as attributable to differences between men in the control group is probably attributable to "noise" - that is something inherent in each man. If this latent noise factor was significant, it would be shown by a partial coefficient of correlation analysis.

If the hypothesis - all managers, irrespective of training, industrial background, or physical location, will respond the same way, were true, one would have expected a correlation between the Job Relation Factor, and the Learning Factor and the Control Set to be more or less equal in every group tested. In fact, the correlation of Job Relation to Control was +0.082; of Learning to Control +.206; but for Job Relation to Learning it was +.673. To demonstrate that noise caused any correlation between L and C or JR and C, and that the response was not caused by a general euphoria, a

partial coefficient of correlation analysis yields:

$$r\ JLC = +0.6728$$

that is - the correlation between Learning and Job Relation is true, and not in any way created by something inherent in the men tested. This test was performed on the data for the second group of Engineers as the Analysis of Variance showed that they had the greatest dispersion in responses.

CONCLUSIONS

In essence, what the respondents are saying, is that if they liked the exercise, it gave them a deeper insight into their job. If they liked the exercise, their attitudes show that they feel that they learned something which is related to their job.

I have shown two groups of statements (Job Relation and Learning Factors) to which a group of managers have given two very definite patterns of response. Although these patterns of response were different to each Factor, the Factors themselves were highly correlated to one another. An analysis of the wording of the two groups of statements shows that they are quite different in

nature, and this correlation cannot therefore be explained by acquiescence. It is, therefore, meaningful. This meaningfulness can best be examined by expressing each Factor as a single statement, encompassing all seven items.

The Job Relation Factor may be stated: Participation in the game revealed areas for improvement in my management abilities and techniques. I have found improvement which I attribute to the game, particularly in decision taking, use of information and approach to problem solving.

The Learning Factor may be stated: The game has been a practical and enjoyable method of training for me. It has been more beneficial than other short forms of management training, and I would recommend it to other managers, and would like to participate again.

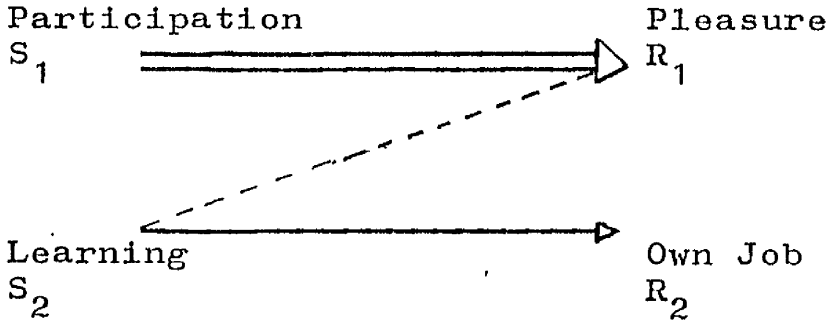
The correlation, therefore, is between improvement in management ability on the job and an enjoyable and beneficial training method. George Mouly states:

> "Pleasure, whether in the form of the quiet satisfactions in daily life or the more

violent joys, is essentially a matter of the satisfaction of one's needs - or to be more correct, of one's motives."[18]

I have shown that those who derived the greatest pleasure had the greatest "satisfaction of needs" - improvement in management ability. Similarly, the correlation means that those who had the least satisfaction learned the least.

J.B. Watson[19] showed that the simultaneous presentation of two stimulus - response bonds is likely to result in an association of the stimulus of the weaker bond to the response of the stronger. Below I show graphically what this correlation has shown:



18. G.J.Mouly. "Psychology for Effective Teaching". Holt, Rinehart and Winston. New York, 1960.

19. J.B.Watson and R. Rayner. "Conditional Emotional Reactions". Journal Experimental Psychology, 3. 1920.

If participation yields pleasure, then learning is related to the participants job (which is his motive for participation). If these bonds are re-enforced together, then, in subsequent exercises, Pleasure will be directly linked with Learning, even if participation in the particular exercise is not as pleasureable. (Clearly the Participation/Pleasure bond should be re-enforced whenever possible). If this bond became strong enough, it might well carry over to other management teaching techniques. That is - the game could be used to create a learning environment (see Chapter 12).

The last way to examine the correlation coefficients between Learning and Job Relation is item by item. A matrix is given below:

CORRELATION COEFFICIENTS FOR JR AND L FACTORS - ALL ENGINEERS

JOB RELATION

LEARNING	36	1	24	3	41	10	59
63	0.560	0.475	0.509	0.565	0.496	0.412	0.566
13	0.313	0.405	0.457	0.427	0.283	0.381	0.427
61	0.284	0.093	0.263	0.276	0.109	0.193	0.399
15	0.401	0.308	0.333	0.384	0.215	0.371	0.479
57	0.452	0.442	0.511	0.581	0.464	0.416	0.399
23	0.390	0.485	0.362	0.528	0.307	0.543	0.494
2	0.321	0.346	0.357	0.464	0.302	0.240	0.474

ALL POSITIVE

Eight of these individual correlations are greater than +0.500. Four relate to; Recommendation to fellow managers. These are:

Use of information affected.

Improvement in management ability attributable to the game.

Change in approach to management problems.

Help in solving day-to-day problems.

Clearly the respondents feel that the game has helped them in these specific areas, and that it might offer the same help to their colleagues.

Of the other high correlations, the most notable is the highest +0.581 - 3/57 - Change in approach to management problems/Value of game greater than equivalent time on management lecture course. As probably all the respondents have attended short courses of management lectures, they very strongly feel that the particular subject of "Approach to Management Problems" is better taught by games than lectures.

C H A P T E R 11

FURTHER RESULTS

RELIABILITY

In Chapter 10 I demonstrated the validity of the test and its results., That is - I demonstrated that the use of the questionnaire produced significant conclusions. Before I discuss the results, however, it is necessary to check the reliability of the test - that is having measured what it should measure, how far can we depend upon the results.

If I could demonstrate that the correlations discussed at the end of Chapter 10 were significantly different - that is to say that the correlation between Learning and Job Relation is significantly higher than the other two correlations, this would demonstrate the reliability of the test. The contribution of r in samples from correlated universes is skewed, and its standard error is difficult to estimate. However, both the sample correlation coefficient and the hypothetical value can be transformed to a quantity called z

whose sampling distribution is nearly normal even for correlated universes. The quantity z is called 'Fishers z - Transformation of r'.

The z transformed values of r are:

	Correlation Coefficient	z value
rJL	0.673	0.817
rJC	0.206	0.209
rLC	0.082	0.083

The standard error of z equals 0.2425. Comparing rJL to rJC:

$$(z - z^1)/\sigma = 2.507$$ Significant at 1%.

Comparing rJL to rLC:

$$(z - z^1)/\sigma = 3.026$$ Significant beyond 1/10 of 1%.

This shows that the same individuals' responses to different group-blocks of questions varied extremely significantly. That is - the test is dependable.

LOOKING AT THE MEANS

The grand mean for all printers was 3.489 and the grand mean for all engineers was 3.520 which are for all purposes the same. It is therefore impossible to draw

any inferences about the difference between these groups from the gross mean data. Further examination of the inter-group differences between printers shows a similar lack of significance. However, the difference between the mean scores for the Learning Factor and the Job Relation Factor are highly significant.

Printers Group	1	6
Learning	4.071	3.880
Job Relation	3.132	3.143

This will be discussed later in this chapter.

The inter-group differences for engineers are significant. Earlier I mentioned the difficulties encountered by the second group of engineers and mentioned the steps which we had taken to overcome these difficulties for subsequent groups. To examine the effects that this change had, I selected two new groups of items for means analysis. These groups are those items which had respectively the highest and lowest mean scores for all engineers tested.

The highest class is made up of those items which

have a mean score for engineers greater than +4.100. They include:

4	4.480	The games were a source of mental stimulation to me.
17	4.467	I maintained a high degree of interest throughout the exercise.
20	4.333	There was a marked rivalry between the teams.
23	4.307	Playing the game is not a waste of time.
29	4.307	The exercise was of value to the participants.
34	4.147	The model was not too complex to expect me to make any useful analysis of it.
40	4.107	Overall, I had a favourable reaction to this new experience.
44	4.347	I found the game extremely enjoyable.
50	4.200	Once involved I felt the simulation was realistic enough to demand my constant attention during the game sessions.

The lowest class was made up of those items which have a mean score for Engineers less than 3.000. They include:

7	2.920	I learned a new way to handle management information.
9	2.600	Even if the players can spot the mathematics of the model in the computer, they cannot perform well unless they can manage.
13	2.787	I have had some benefit from participating in this business game and feel there is need to repeat the exercise.
19	2.827	This game was the most useful two days' management training I have ever had.
26	2.600	The results of the game do indicate who are the best managers.
38	2.373	The structure of the game was such that it considered many important variables in an industrial situation.
41	2.787	There has been a positive change in my ability to take logical decisions.

ENGINEERS CLASS MEANS - BY GROUP

ENGINEERS	HIGHEST.	LOWEST.
Group 1	4.322	2.654
Group 2	3.917	2.271
Group 3	4.485	2.970
Group 4	4.536	2.908
Average Groups 3 & 4	4.511	2.939

Those variables in the highest class relate to enjoyment of, and stimulation from, the exercise. Those in the lowest class include three items relating to the respondents job and four items about the game. The table above shows how significantly group 2 varies from groups 3 and 4, Group 2 highest and lowest scores respectively 3.917/2.271, Groups 3 and 4 respectively 4.511/2.939.

THE IMPORTANCE OF PARTICIPANT SATISFACTION

This means that by altering the pressure on the participants to produce high profits, we have been able to significantly alter the attitude towards the exercise and towards its usefulness. The changes mean that each team was starting with a different asset position both physical (stock and production facilities) and cash. It also means that each team was starting with an overall marketing policy (quality and price) already established.

Most game players wanted to produce the best apparent performance (gross assets at the end of the exercise) in front of their peers. By placing the

participants in a position where it would be very difficult to evaluate this asset position, because of the disproportionate start, we ensured that the participants would concentrate on the Learning elements of the exercise. With the frustration of failure removed decision taking was at a much higher level. The sociometric analysis carried out during all games showed very much higher responses from all teams in games 3 and 4. The morale was high because even the teams who were not performing best from a profit point of view had the disproportionate start to relate to their performance.

The examination of the table of Analysis of Variance in Chapter 10 yields the following figures for the sum of squares relating to the source of variation attributable to difference between men.

	1		2		3		4	
	Sum of Squares	F	Sum of Squares	F	Sum of Squares	F	Sum of Squares	F
Learning	62.6	4.51	88.8	8.57	30.4	3.67	20	3.29
Job Relation	57.6	5.42	88.7	7.56	52.9	7.99	35.6	4.76

Although all the figures are significant beyond 1/10 of 1%, the figures for Group 2 are substantially higher than for any other group. This means that the scatter between individuals was greatest in that group. This is clearly accounted for by some ~~very high~~ individuals who did extremely well and some other individuals who did poorly. What this shows is that the overall reaction of the participant to the exercise will be very much influenced by the level of his morale during the exercise. and his ability to make a reasonable showing during the exercise. This conclusion is reinforced by noting that Group 1 had the second highest scattering for both the Job Relation Factor and the Learning Factor. In other words the lowest scatter is all produced after the changes were made which lowered the tension levels.

There is still further proof available of the enormous importance of the participant enjoying and feeling confident during the exercise. This is the high

correlation between the Job Relation Factor and the Learning Factor. High scores in the Job Relation Factor mean high scores in the Learning Factor. We have already seen earlier in this chapter that the mean for all Learning items was significantly higher than the mean for all Job Relation items. This correlation is therefore most important. The respondent who enjoyed the exercise and had a positive feeling towards it apparently carries more of the learning from the exercise into his job. Clearly if the participants effort leads to satisfaction, he reacts favourably to the learning situation. The utility of the exercise is correlated to the participants enjoyment of it.

Factor one, the Job Relation Factor, has the highest loading explaining 38.4% of all variance. This means that the respondents, being professional men, oriented the high consistency of their response to the relation that they felt the exercise had to the day-to-day job which they did. The high correlation with the second factor, Learning, indicates that this consistency of

response was also consistent with satisfaction in participating in the exercise.

Therefore, one of the clearest results that I can state from this research is that to have the greatest utility, games must be written such that they provide all participants with the possibility of successful performance, and that all steps are taken by the game designer to ensure that participants' anxieties are minimised.

CONCLUSIONS

In the preceeding chapters I produce a great many statistics which I feel I should re-examine to draw conclusions on the results of my work. I show that with no reminder the response rate to my questionnaire is 64.7% (Printers) and with one reminder 83.3%(Engineers). I show that even 17 months after the date of participation 61.8% of the participants responded to a questionnaire which takes fully 30 minutes to prepare. Although I have no yardstick to compare this performance to, I know from discussions with other researchers that it is

extremely high. This shows that the participants maintained a very high level of interest in this learning device irrespective of whether their opinions were favourable or unfavourable.

I show that the responses of the Printers, who participated in a simple version of the basic game and played for only 4 hours in a one day course, correlated almost perfectly with the responses of the Engineers. The Engineers on the other hand, had participated in a complex game with 11 hours of play over 3 days.

I then, with various tests of the internal validity of the questionnaire, demonstrated that this high correlation was not an artifact created by something that is inherent in all managers. I showed that the questionnaire was measuring the attitudes of participants towards my game.

I showed an extensive correlation analysis comparing all responses to each question to all responses to each other question. This correlation was the basis of the Factor Analysis, but it is interesting to note several

of the extremely high correlations shown by it:

19/52 +0.668 - This game was the most useful two days management training I ever had/ The game has had a more lasting impact on my management thinking than any other short training programme which I have participated in. It is interesting to note that the respondents highly relate usefulness of the game to the lasting impact on their thinking!

24/36 +0.591 - After the time elapsed I can find areas of improvement in my management ability attributable to the game/ My use of information has been affected by participation.

This is interesting because the average time elapsed is greater than 10 months and the implication is that the change in management ability relates to the use of information. One of the serious problems in both "Caxton" and "West" is the need to assess only the pertinent data in attempting to take a decision within the 20 minute decision time allowed.

30/57 0.590 - The game gave me additional insight into my process of decision taking/ A two day course of

lectures on a management subject would not have been of greater value.

This is interesting because clearly the participants relate the learning, which they feel has been significant, to the area of decision taking. They also seem to indicate that this is the area they feel, after participation, is most usefully taught using games.

3/30 0.521 - There has been a change in my approach to management problems/ The game gave me additional insight into my process of decision taking.

This reinforces correlation 30/57.

My Factor Analysis yielded two major factors. The Job Relation Factor explaining 38.4% of all variance, and the Learning Factor explaining 7.9% of all variance. A factor is a group of questions to which the 219 respondents have replied consistently. The high proportion of variance explained by the first factor shows the very high level of this consistency. Here the respondents were being consistent about how they felt the subjective learning device to which they had

been exposed, affected their performance and ability in their day-to-day job.

The very fact that such a factor should emerge must be extremely encouraging to educators interested in simulation techniques. The fact that it correlates so highly with the respondents view of the learning gained from, and enjoyment of, the simulation, means that we have found a tool which, at least, this group of managers, feel, gives them a learning environment which they can and do always relate back to the job which they do.

I must emphasise the importance of this point. In a formal learning situation in a class room where the teacher is "teaching" facts which are true and objective, we expect a high acceptance level on the part of the student. With these games we were offering a new informal subjective learning tool to the student. It is a learning tool in the areas where he spends his working life. The acceptance of this learning tool and its lessons by the respondents is therefore most important.

To sum up then, the things which I have clearly shown are:

That the two games used in this analysis are important tools for learning in the area of management studies.

That the test which I developed is a valid and reliable tool for measuring the usefulness of this type of learning situation.

That if a participant's efforts lead to satisfaction, he reacts favourably to this type of learning situation; and that the utility of this learning situation is closely related to the enjoyment thereof.

C H A P T E R 12

THE FUTURE

The work which I have done has indicated to me three areas for further development following on my thesis.

a. Controlled Learning Environment.

b. Testing the Controlled Learning Environment.

c. The use of this Test for evaluating subjective opinion about comparable learning experience.

CONTROLLED LEARNING ENVIRONMENTS

At the beginning of this thesis I stated my opinion that Management Games are not a complete management programme. This thesis has shown that they are an extremely useful device for providing a learning environment in such areas as decision taking, the use of information, simple quantitative analysis, and group psychology. However, there are many more areas of management teaching which can be, and are being, more adequately covered by literature, case study, problem

solving, and simple research.

The fact that simulation can get students highly involved and interested in a learning environment, leads to my suggestion in this area. A game should be written which would be used as the basis of a management course. When the participants commence the course, ~~arrived~~, a simple version of the game would be played to provide the environment and involvement necessary for the programme. All that took place afterwards would then come back and make reference to the environment created by the game. The lectures would relate to problems thrown up by the game. Case studies would involve the game companies.

In the background would be a complex version of the original game. When it was decided to teach facts and concepts about marketing, the marketing "window" of the game would be opened, and the teams would be allowed to compete in a complex marketing environment which they already knew. They would have to take decisions about price, about sales promotion, about advertising, about salesmen, etc. They could be "forced" into studying such concepts as marketing mix analysis where the "force"

was in fact their desire to perform well in an environment within which they were stimulated. A computer would optimise all the other decision areas for the team.

When it came to dealing with the subject of finance, the financial "window" would be opened and the marketing element would go back to that part of the game being optimised by the computer. All the problems of financial control, the provision of capital, budgeting, etc. would then have to be done by the teams under the supervision of the financial tutor. The machine would optimise every decision in relation to the financial decisions being taken.

This procedure would be followed for production, production control, research, development, etc. During each part of this programme the tutor would direct his teaching towards the game environment and the teaching examples which he used would be used in the context of this environment.

At the end of the course, which depending upon the

complexity of the game, ~~which~~ might be six weeks to one year in duration, the participants would have to "play" the whole integrated game with all the "windows" open.

The writer can envisage certain problems inherent in the introduction of this technique. The game would require the use of one channel of a multi-access computer being open and available during most teaching hours for the use of the game. The teaching staff would most probably themselves need to be retrained to allow the participants to maximise their benefit from the programme. There might be certain elements brought into the environment which could not be adequately settled without the intervention of the game controller. An example of this might be a role playing exercise to settle a strike where no settlement is achieved. A settlement might have to be imposed to allow the course to continue within the game environment.

Overall, however, if this technique is as useful as it appears to be from the analysis, in providing the learning environment, then the way to take full advantage of it is through - Controlled Learning Environment.

TESTING THE CONTROLLED LEARNING ENVIRONMENT

I have used my test to test the subjective attitudes of individual participants. I would be interested in seeing an experimental test within a single industrial firm.

The attitudes and performance of all levels within the firm should be tested; then, an extensive Controlled Learning Environment programme should be initiated within the firm at all management levels. After the training period I would want to re-examine the attitudes and performance of the firm.

The examination of attitudes would relate not just to attitudes towards the training, but attitudes towards the firm, towards superiors, subordinates, etc. The measures of performance would be productivity and profitability.

I feel that the results of this type of analysis will allow the growing body of management educators greater access into the large body of untrained management.

THE USE OF THIS TEST FOR EVALUATING SUBJECTIVE OPINION ABOUT COMPARABLE LEARNING EXPERIENCE.

Although this area is not directly in the field of management games, I feel that it may possibly be the most important outcome of this research. I have demonstrated that this test is a valid and reliable tool for measuring subjective opinions about an informal learning tool. The need to assess learning environments is beyond any question. Every educator from the Ministry down to the teacher would like to know how effective teaching is.

In the September, 1966 "New Education" Professor J.V. Edling states:

> "There is very good research evidence that the present procedure of using expert opinion as a basis for evaluating programme effectiveness is the worst possible method. It has repeatedly been shown that there is a high negative correlation between expert opinion of the effectiveness of instructional materials and actual learning as demonstrated by student

> test performance. This, of course, means that materials rated <u>least</u> effective proved <u>most</u> effective. The needs of the naive learner appear to be very different from those of the sophisticated. Studies have even shown that an experienced teacher, teaching outside his discipline, improves on the performance of the expert. In one study, four experts disagreed on teaching method, and in a carefully controlled experiment, only the control group - that is, the group that received no instruction at all - scored significantly higher on the criterion measures than any of the taught groups. All the evidence would suggest that the best way to determine whether a programme is any good or not is to see whether students learn from it."

I have shown that students do learn from my teaching method and further, that I have a tool with which to measure the effectiveness of the method. I have only shown this measurement tool's use in evaluating an

informal learning tool in the area of management studies. I can conceive of the same type of test instrument being used to evaluate other forms of management teaching which are informal and involved group participation to create a learning environment, such as case studies and T groups.

There is, however, no need to confine the possible use of this technique to the field of management studies. I can find immediate parallels in other fields of knowledge where the technique might be applicable:

Games used in political science.

Role playing court in law.

Group work in psychology.

Seminars in literature.

In the same issue of "New Education" Barry Turner says:

> "It is a fundamental truism of education that no one really knows how to teach. A student is fed on rules and maxims which derive from his tutor's personal experience, prejudices and idiosyncracies. In the

> classroom situation he (the teacher) is very much on his own and relies on his personality and enthusiasm to get across whatever specialist information he has to offer. His degree of success nearly always falls far short of his expectations. The teaching apparatus of a modern school - the teaching machine language laboratory, television set - are not the answer to the problem. What is needed is a comprehensive theory of instruction based on a scientific analysis of the nature of learning and intellectual growth."

As a teacher I agree entirely with what Mr. Turner says. I feel that my test may, therefore, be the basis on which the "scientific analysis of the nature of learning" may be done in relation to informal group learning.

I must re-emphasise that I have only demonstrated the validity of this test in relation to the two specific games included in the thesis. Its extension to other games and other techniques is conjectured, but the validity of this test is very high, and the need for other tests in other areas is very great. It would, therefore, seem worthwhile to at least analyse its validity in another area.

A P P E N D I C E S

APPENDIX I

MUTECH SIMULATION

In MUTECH we simulated a machine shop of medium size (1,200 employees) engineering works in the Manchester area. The data presented although in many cases simplified and accumulated, is all real and based on the day-to-day realities of that shop. There are four products produced:

1. Focussing Reflector - spare for a miner's cap lamp.
2. Torches - Pressure and waterproof torch used by the Admiralty.
3. Booster Sockets - This is an appliance fixed on the outside of public buses to allow the use of a mains electric current for starting the engine when cold.
4. Traction Charger - These are used for recharging batteries used in traction vehicles. An example of the complexity of the exercise is given by the PERT Flow

Chart for the manufacture of Traction Chargers (see below)

The starting operating unit is small (5 machines with operators and 4 assemblers) but there are a number of machines made available in each production area to increase plant capacity.

Briefly the chief decision areas are:

Materials Control

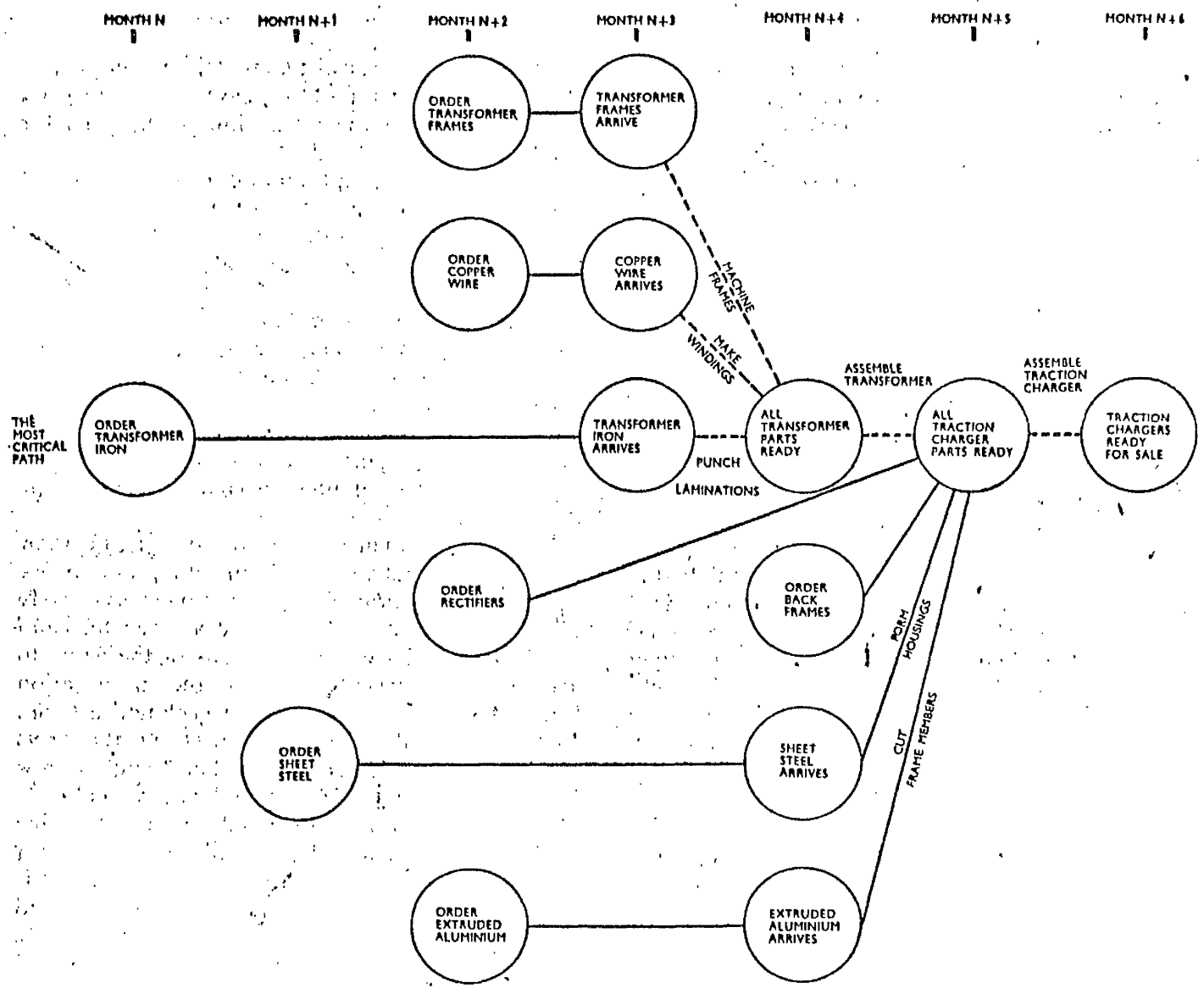
There are three basic areas for control, raw materials and bought-out components, manufactured components and finished goods.

Production Control

Here the participants have to optimise the use of existing facilities. Investment analysis is also important to determine the value of further tools and personnel

Finance

Demand expands within the game play and the control of the financing of this expansion is one of the keys to success.



PERT FLOW CHART FOR THE MANUFACTURE OF TRACTION CHARGERS

APPENDIX II

PATENT APPLICATION NO. 23324/63

COMPUTING APPARATUS

This invention relates to computing apparatus adapted to give a solution to equations of the form

$$\Sigma_i = \Sigma_{a=1}^{n} f_a(V_a) + \Sigma_{a=1}^{n} K_a V_a'$$

$$= f_1(V_1) + f_2(V_2) + \ldots\ldots f_n(V_n) + K_1 V_1' + K_2 V_2' + \ldots\ldots K_n V_n'$$

where Σ_i is regarded as the solution, K_1 .... K_n are constants and V_1 .... V_n, V_1' .... V_n' are variables (hereinafter termed an equation of the form referred to), particularly, though by no means exclusively, suitable for use in management training simulations.

The invention is based on an appreciation of the possibility of summing the current outputs from a plurality of function generators constituted solely by passive networks as a means of obtaining a solution to an equation of the form referred to.

Thus, according to the invention, apparatus for solving an equation of the form referred to consists of,

for each non linear term on the right hand side of the equation a non linear function generator adapted to give a current output of $i_a = f_a(V_a)$ when given a voltage input of V_a, for each linear term on the right hand side of the equation a linear function generator adapted to give a current output of $i_a = K_a V_a'$ when given a voltage input of V_a', means for supplying each function generator with a desired voltage input derived from a potentiometer, means for summing the current outputs from all the function generators, and means for displaying the resultant summation, each said function generator being constituted by a passive network.

According to a preferred feature of the invention each said non linear function generator is constituted by a plurality of biased diode circuits arranged in parallel.

According to a further preferred feature of the invention each said linear function generator is effectively constituted by a single resistance.

According to a still further preferred feature of the invention, said means for summing the current outputs of all said function generators comprises a Kirchoff adding network.

These and further features of the invention will be apparent from the following description with reference to the several figures of the accompanying drawings, which show in schematic form, by way of examples only, one form of computing apparatus embodying the invention.

Of the drawings:-

Fig.1 is a block circuit diagram of the computing apparatus;

Fig.2 is a circuit diagram of one of the linear function generators of Fig.1;

Fig.3 is a graphical representation showing the behaviour of the linear function generator of Fig.2;

Fig.4 is a block circuit diagram of one of the non linear function generators of Fig.1;

Fig.5 is a circuit diagram of one of the biased diode circuits of Fig.4;

Fig.6 is a graphical representation showing the behaviour of the non linear function generator of Fig.4;

Fig.7.is a perspective view of the case of the apparatus showing the relative positions of the various parts thereof;

Fig.8 is a plan view of the control panel for one of the non linear function generators; and

Fig.9 is a plan view of the control panel for one of the linear function generators.

Consider first the equation which is to be solved by the apparatus.

$$\Sigma_i = \sum_{a=1}^{n} f_a(V_a) + \sum_{a=1}^{n} K_a V_a'$$

$$= f_1(V_1) + f_2(V_2) + \ldots f_n(V_n) + K_1 V_1' + K_2 V_2' + \ldots K_n V_n'$$

Referring now to Fig.1, the apparatus has a function generator FG for each term on the right hand side of the equation. The function generators FG are of two kinds non linear and linear respectively. The non linear function generators are identified by the references $FG\mathcal{f}_1$, $FG\mathcal{f}_2$ ..... $FG\mathcal{f}_n$, and the linear function generators are identified by the references FGK_1, FGK_2 ..... FGK_n.

Each non linear function generator is adapted to give a current output $i_a = \mathcal{f}_a (V_a)$ when supplied with a voltage input of V_a, and each linear function generator is adapted to give a current output of $i_a = K_a V_a'$ when supplied with a voltage input of V_a'.

For each function generator, a potentiometer P is provided and is connected between an H.T. source and earth, the movable contact of the potentiometer P being connected to the input of the function generator. The movable contact of each potentiometer P is adapted to be connected with the movable contact of a master

potentiometer MP via a galvanometer forming a null meter NM by means of a spring loaded switch S. The spring loaded switches S are normally held in the open position (as shown on Fig.1) but may be actuated against the action of their springs to make the connection described. The master potentiometer MP is connected between the H.T. source and earth. The outputs from all the function generators FG are connected to earth through resistances R forming a Kirchoff adding network and an ammeter forming an output meter OM.

In use, a desired voltage input is supplied to each of the function generators in the following manner. The master potentiometer MP is adjusted so that its display records the desired voltage input for the first function generator and the switch S associated with this function generator is depressed, and its associated potentiometer P adjusted to give a zero reading on the null motor NM, the switch S is then released, when it will be appreciated that the function generator is receiving an input voltage equal to that originally set

on the master potentiometer MP. The process is repeated for each function generator which is required for the solution of any particular equation, until all are receiving the desired voltage inputs.

It will be appreciated that the output meter OM records the sum of the output currents from all the functions generators and hence indicates the solution to the equation.

Referring now to Fig.2 it will be seen that each linear function generator comprises a plurality of resistances, identified by the references R_1, R_2, R_3 ..... etc. and switch means for selecting any single resistance of the group, the single selected resistance forming the operational part of the function generator.

Referring now to Fig.3 the relationship between the current output i of the linear function generator and the voltage input V is shown. Suppose the resistance selected has a value R, then $i = \frac{1}{R} V$ which can be identified with the general linear term on the right hand

side of the equation $K_a V_a' = ia$.

Referring now to Fig. 4, it will be seen that each non linear function generator comprises a plurality of biased diode circuits arranged in a parallel network. The biased diode circuits are identified by the references D_1, D_2, D_3 ..... etc.

Each biased diode circuit D consists of fixed resistances X, Y and Z, and a variable resistance W and a semi-conductor diode T (see Fig.5)

If the current output from the biased diode circuit is plotted graphically against the voltage input, a straight line is produced, but such does not necessarily pass through the origin.

By carefully selecting the characteristics of the circuits D_1, D_2, D_3 .... etc. of each non linear function generator the current output of that generator may bear any desired functional relationship to the voltage input.

For example, referring to Fig.6 the outputs ofthe

diode circuits D_1, D_2 and D_3 of one generator are represented by the lines d_1, d_2 and d_3, and since the circuits are connected in parallel, it will be appreciated that the current output from the network as a whole follows the line A and bears an approximately parabolic relationship with the input voltage.

Referring now to Fig. 7 the computing apparatus described is housed in a desk top metal casing 10. A power pack is housed in the casing 10 on the left hand side thereof, and an on/off switch and warning lamp 11 and 12 respectively, are provided on the front wall of the casing. The master potentiometer MP, null meter NM and output meter OM are positioned on the top of the casing 10 as also are control panels 13 for each of the non linear function generators and 14 for each of the linear function generators.

Each control panel 13 includes the switch S and control for the potentiometer P associated with the corresponding non linear function generator, and each control panel 14 includes the switch S, control for the

potentiometer P and resistance selecting switch O associated with the corresponding linear function generator.

The non linear function generators are preferably comprised by plug in printed circuit boards which can be quickly changed to allow the apparatus to be set up for the solution of any particular equation. The linear function generators may likewise be changeable, though it is envisaged that sufficient resistances may be provided in each generator to enable a selection to be made from same to meet most requirements without the necessity of having additional sets available.

The apparatus is set up for the solution of any particular equation by providing a suitable function generator for each term on the right hand side of the equation, and although the linear function generators described each carry a plurality of resistances, it will be appreciated that only one of such is used when the apparatus is set up for the solution of a particular equation.

The apparatus may be used for simulating all kinds of conditions and may be used for management training simulations. In such a simulation a series of functions are derived wither empirically or by research. These functions then form a model of the business reality within which the trainees will be operating during the exercise. The problem is to take a series of decisions which they have made, and quickly analyse the impact of these decisions on the programmed market.

This may be done for example in an interacting simulation by measuring each expenditure against it's respective function and having the total increase in current measured by the adder. This could be said to equal the total effectiveness of the expenditures made by one team. If the expenditures of each of the other teams is measured in the same way and the total of team totals set equal to 100 the resulting values would indicate each team's share of the market. The function elements in this type of interacting simulation might include; price, sales promotion, T.V. advertising,

newspaper advertising, product development, sales incentives, etc.

It is possible to use the same computer with different functions to solve a non-interacting simulation Here the elements might include; wages, welfare, quality control, quality of input, administrative expense, work study, etc. The result to be read out of the adder might be productivity or cost per unit of output. The two types of training simulations described might be joined together in one exercise which would represent the operation to the total enterprise.

The same basic technique of using a series of exclusively passive elements to build a computing device could be applied to a number of other problems in the management area. They could be used in inventory control both in determining the optimal order quantity and the re-order point. They could be used in investment (or replacement) analysis to determine the compound discounted rate of return on investment and/or the ranking of investment projects. They can in fact be used in

any area of decision making where the critical elements either costs, rates or otherwise, can be represented by one or more linear or non linear functions.

It will be appreciated that it is not intended to limit the scope of the invention to the described example only, many variations of the apparatus, such as might readily occur to one skilled in the art being possible, without departing from the principles of the invention.

PATENT APPLICATION
N° 23324/63

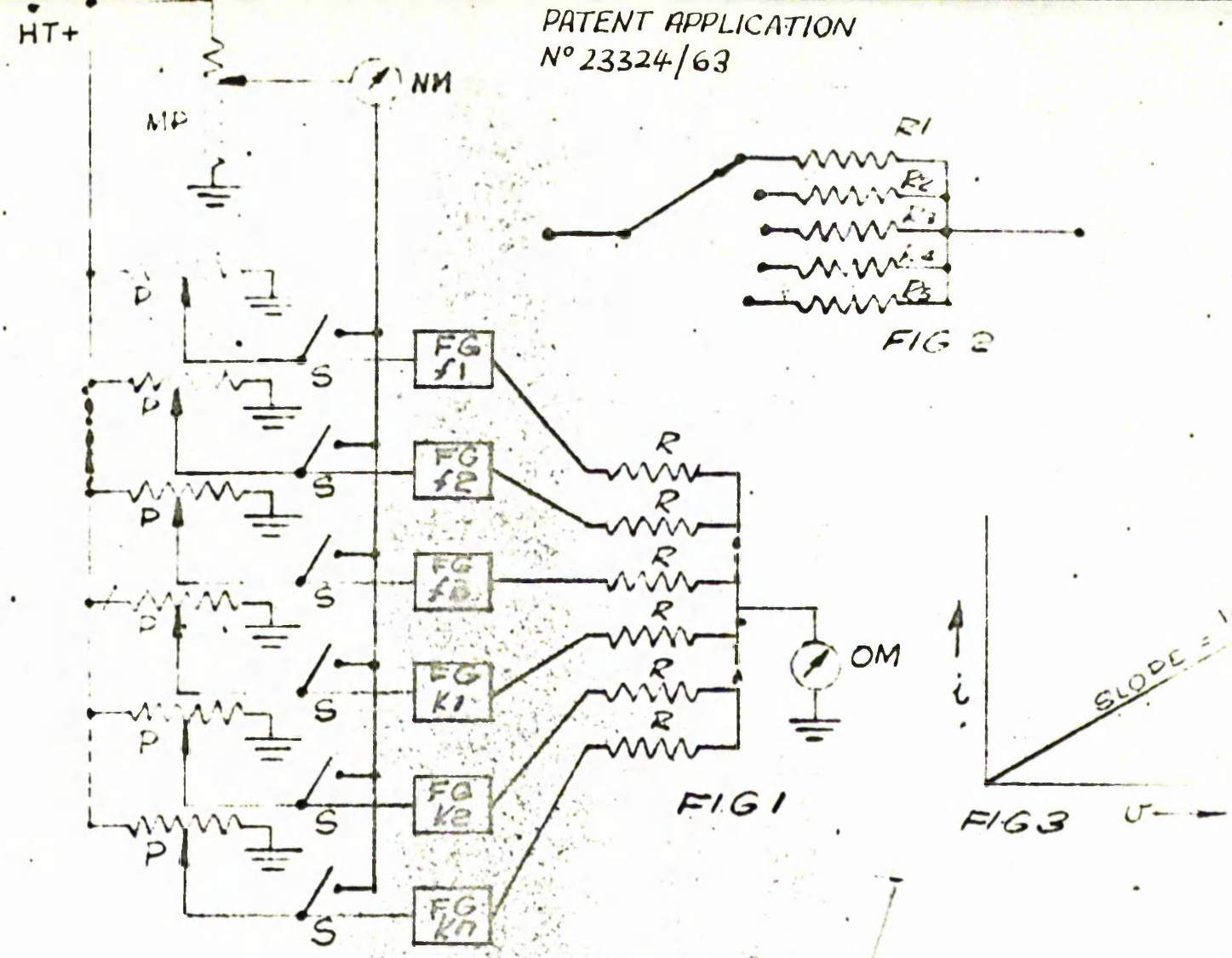


FIG 1

FIG 2

FIG 3

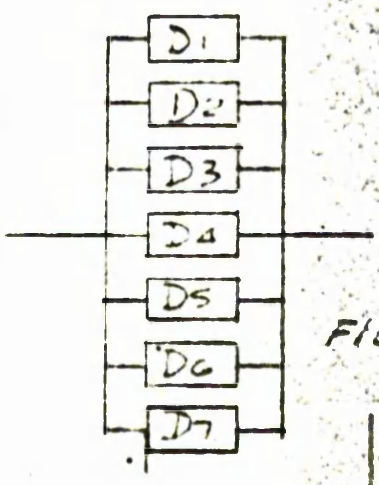


FIG 4

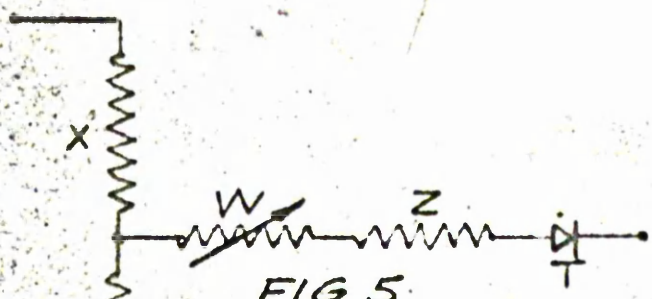


FIG 5

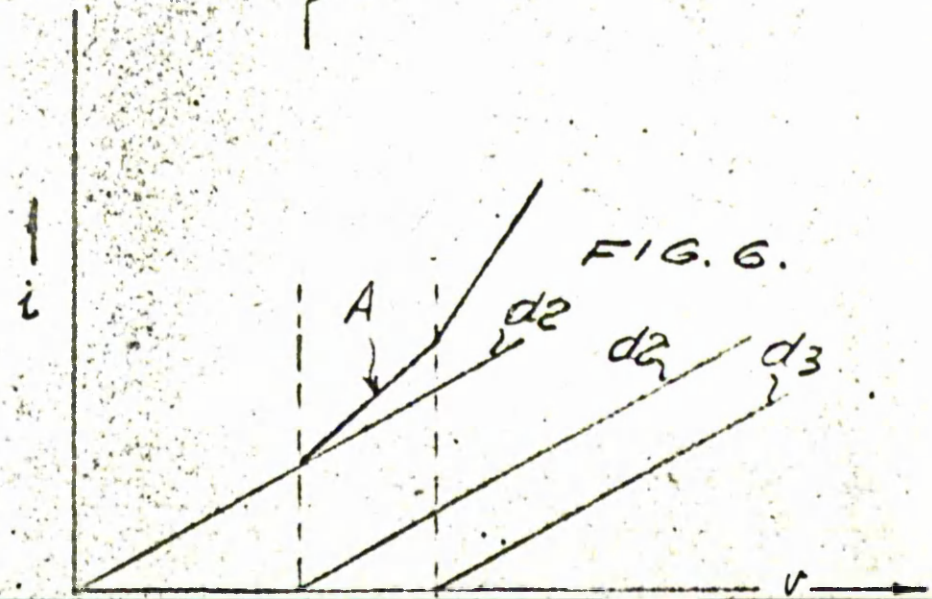


FIG. 6.

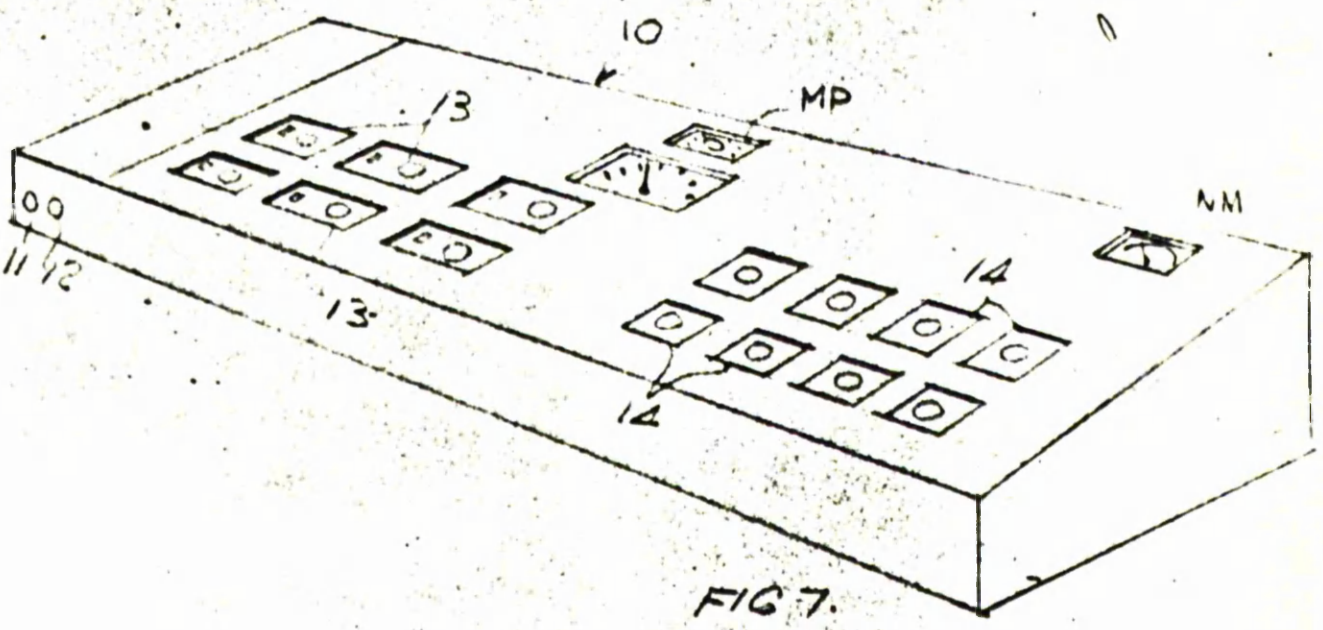


FIG 7.

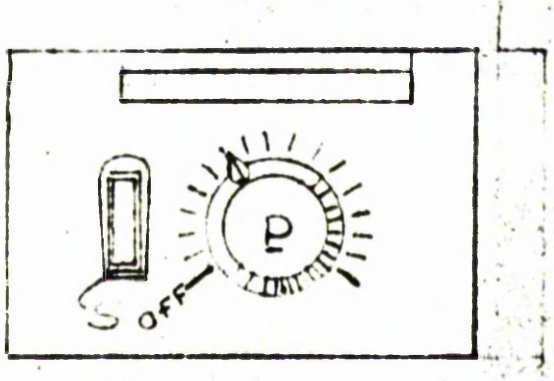


FIG 8

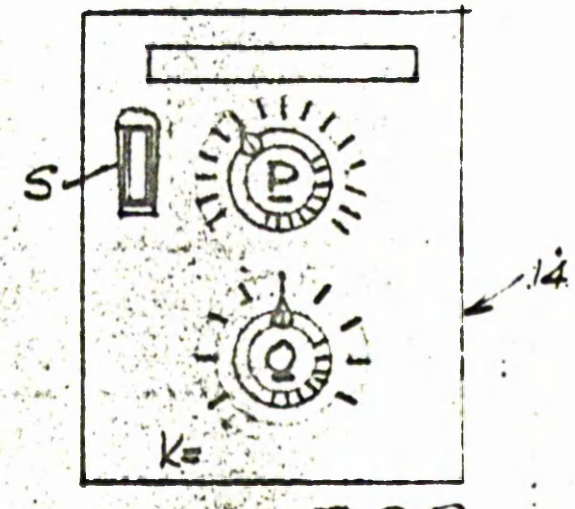
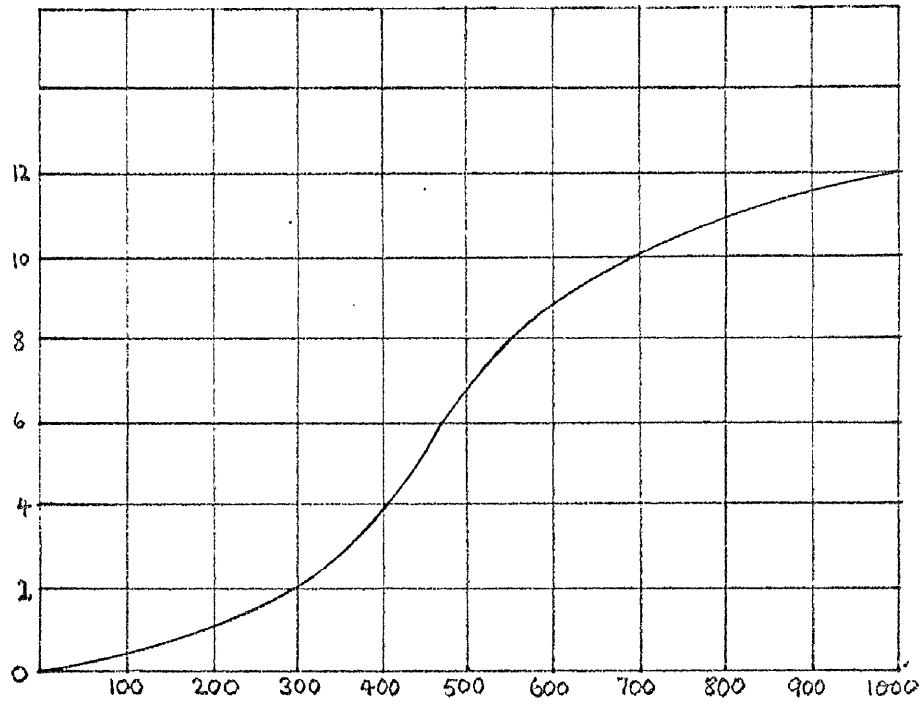


FIG 9

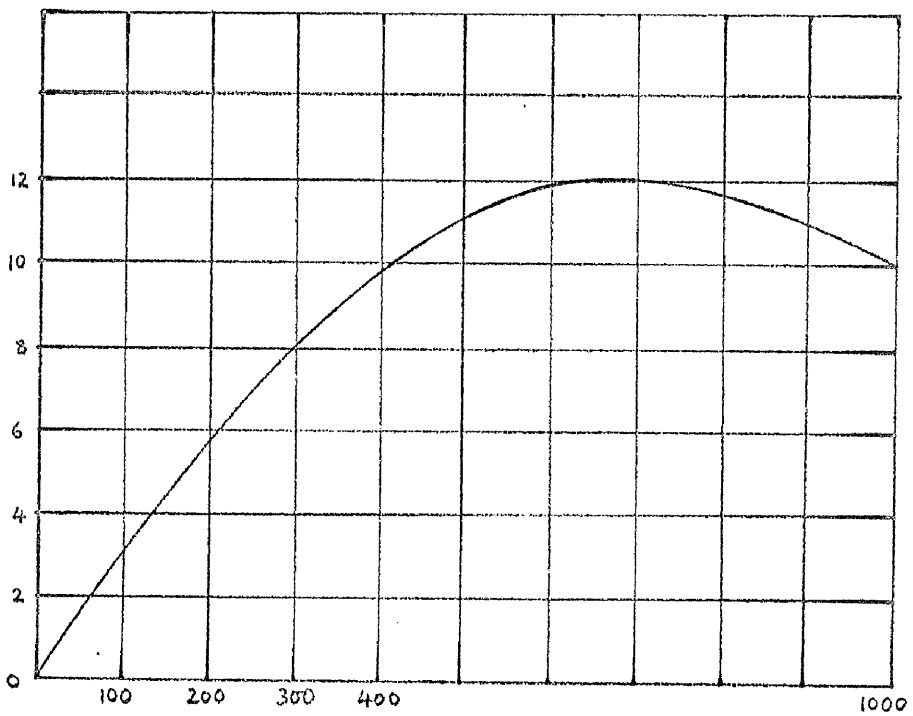
APPENDIX III

5A Selection of Program Function Cards

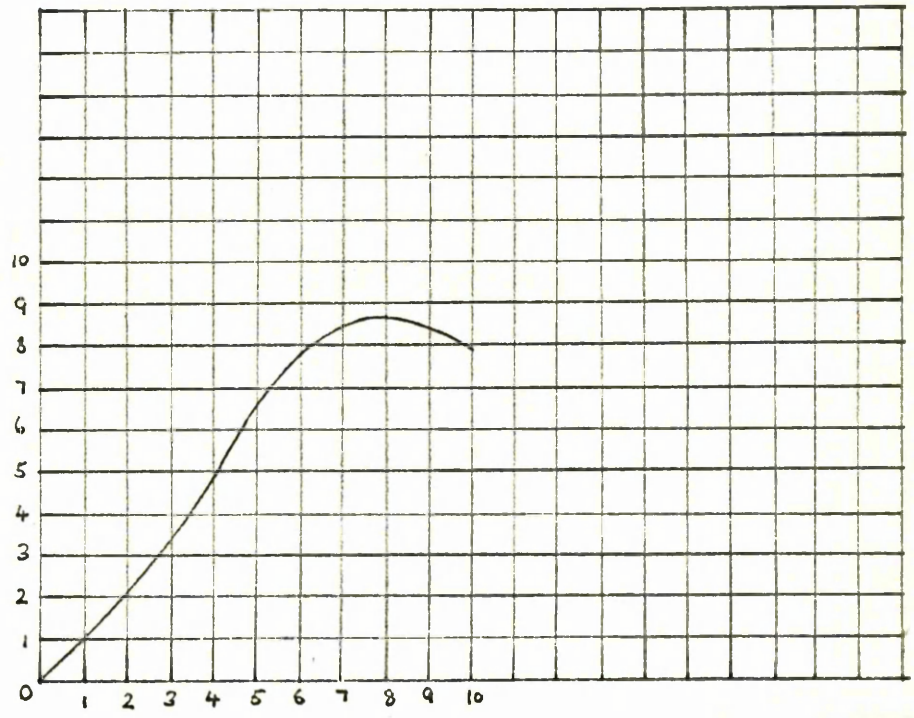
ATHENA COMPUTER



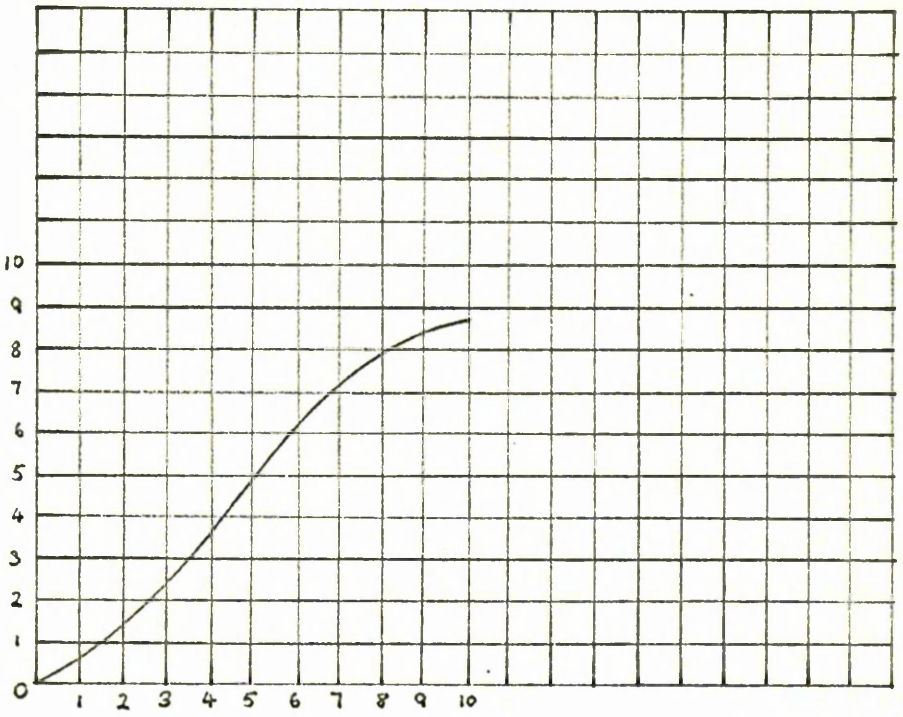
5



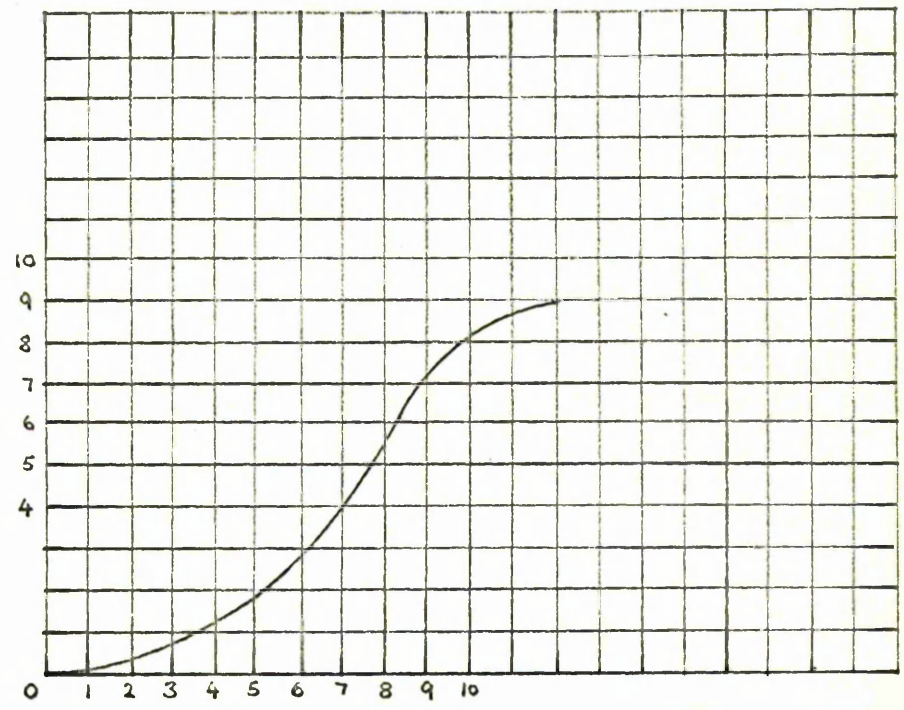
5C



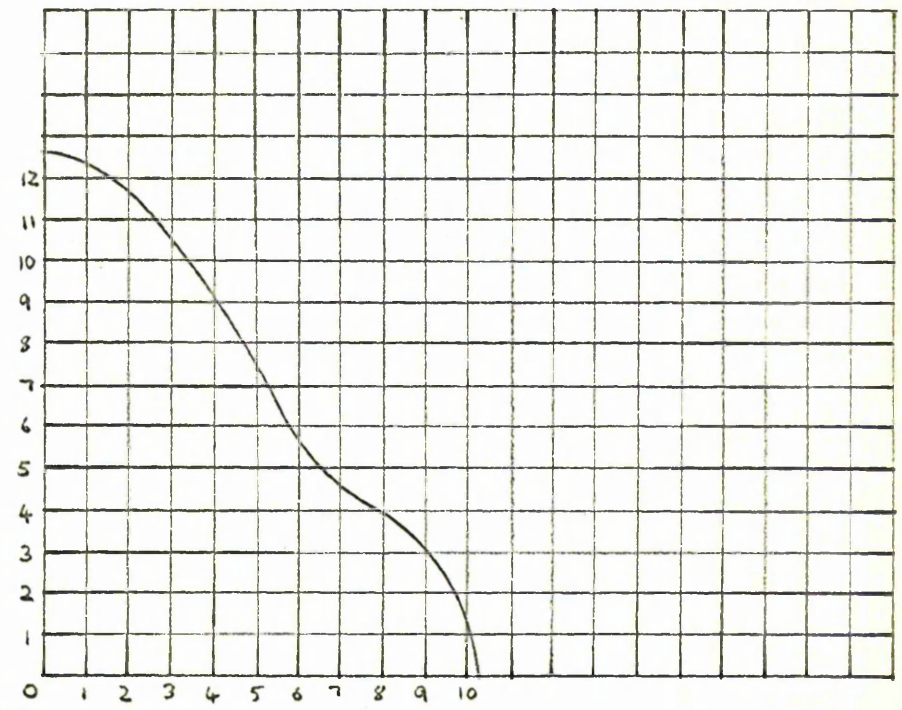
5D



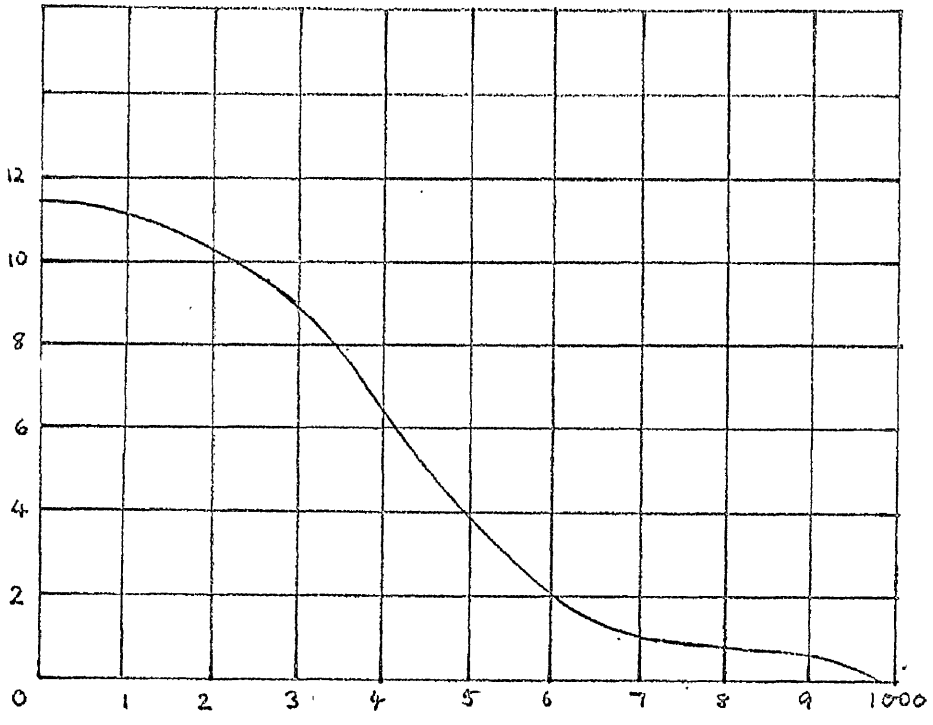
5E



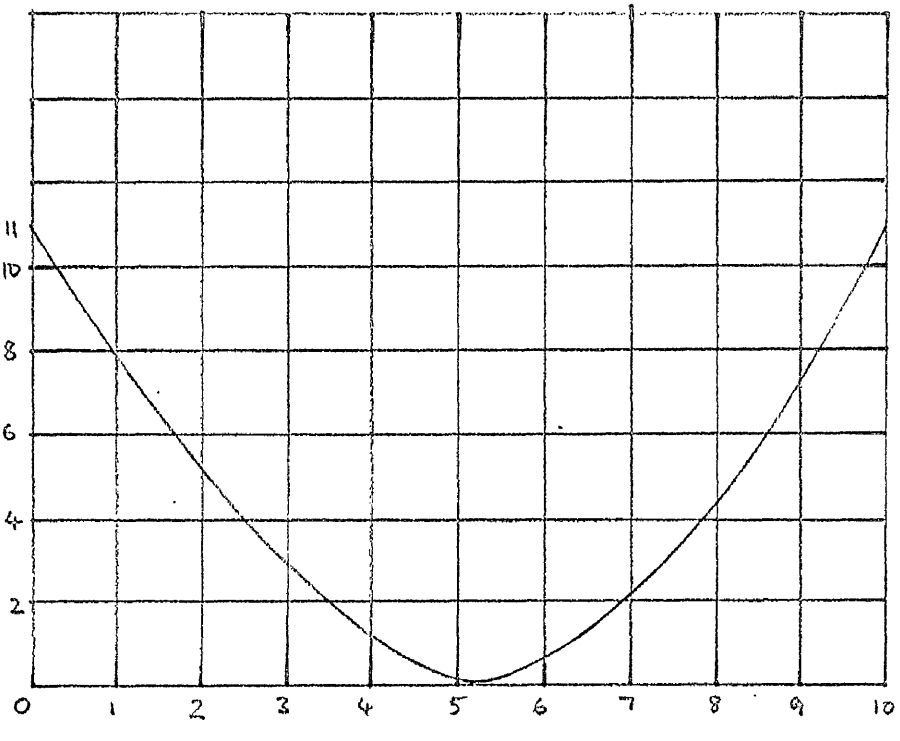
6



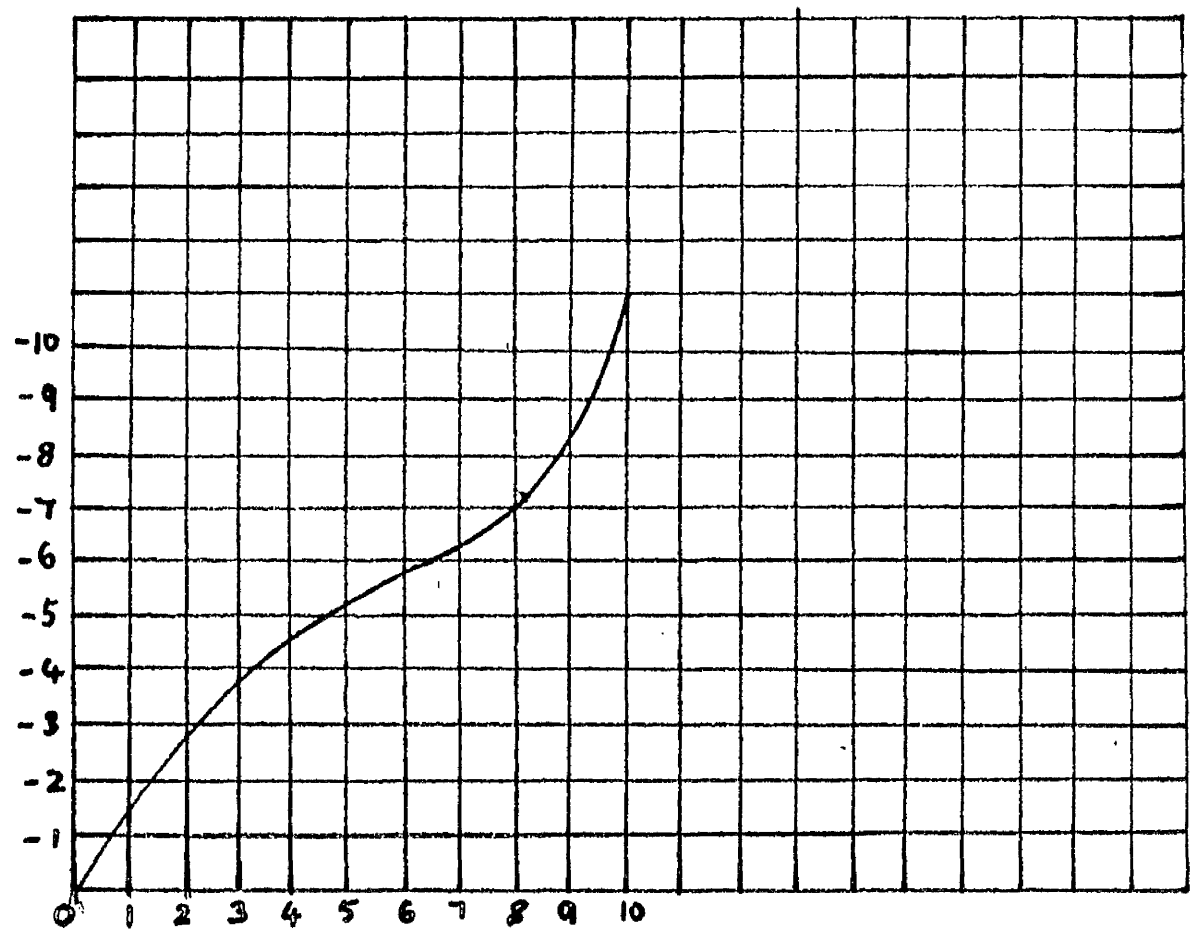
6A



6B



7



APPENDIX IV

SELECTED LIST OF WORK PLACES OF PARTICIPATING ENGINEERS

Group No.1.

Gloucester	Cwmbran	Worcester
Cheltenham	Bristol	London
Swindon	Stroud	Mitcheldean

Group No.2.

Frome	Ratby	Woodchester
Chippenham	Dursley	Glasgow
Weston-S-Mare	Pontypool	

Group No.3.

Hereford	Birmingham	Gloucester
Street	Beccles	
Bristol	Swindon	

Group No.4.

Yeovil	Bath	Birmingham
London	Herts	
Cheltenham	Axminster	

B I B L I O G R A P H Y

Angell, N. "The Money Game". London. Dent. 1928.

Basil, D.C., Cone, P.R., Fleming, J.A. "Executive Decision-Making Through Simulation". Columbus, Ohio. Charles E. Merrill. 1965.

Cohen, K.J. and Rhenman, E. "The Role of Management Games in Education and Research". Management Science VII January, 1961.

Cohen, K.J. et al. "The Carnegie Tech Management Game". The Journal of Business 33, October 1960.

Dill, W.R., Jackson, J.R., and Sweeney, J.W. (eds.) "Proceedings of the Conference on Business Games as Teaching Devices Sponsored by the Ford Foundation and School of Business Administration, Tulane University, April 26-28, 1961." New Orleans. 1961.

Fairhead, J. "The Validation of Business Exercises". Association of Teachers of Management Bulletin No.19. Birmingham. September, 1965.

Fairhead, J., Pugh, D.S., Williams, W.J. "Exercises in Business Decisions". London. English Universities Press. 1965.

Fessler, M.E., Saunders, C.B., and Steele, J.D. (eds.) "Proceedings of the National Symposium on Management Games, December 12 - 13, 1958". Lawrence Kan.: Centre for Research in Business, University of Kansas, May 1959.

Gordon, R., and Howell, J. "Higher Education for Business". Columbia University. New York. 1959.

Greene, J.R., Sisson, R.L. "Dynamic Management Decision Games". New York, Wiley. 1959.

Greenlaw, P.S., Herron, L.W., and Rawdon, R.H. "Business Simulation in Industrial and University Education". Englewood Cliffs, N.J., Prentice-Hall. 1962.

Greenwald, H.A. "Management Games for the Executive". Federation of British Industries Review. July 1962

Greenwald, H.A. "Putting Reality into a Game". Automatic Data Processing. May 1962.

Hartley, M.G. "An Introduction to Electronic Analogue Computers". London. Methuen. 1962.

International University Contact for Management Education. "Management Games". Summary Report. Delft, The Netherlands. 1963.

Kibbee, J.M., Craft, C.J., and Nanus, B. "Management Games: A New Technique for Executive Development". New York. Reinhold. 1961.

Life, A., Pugh, D. (eds.) "Business Exercises: Some Developments". ATM Occasional Papers No.1. Oxford. Blackwell. February, 1965.

McKenney, J.L. "An Evaluation of a Business Decision Simulation as a Learning Environment". Management Technology Volume 3. 1963.

McKenney, J.L. "An Evaluation of a Business Game in an M.B.A. Curriculum". Journal of Business No.3. 1962.

Mouly, G.J. "Psychology of Effective Teaching". New York. Holt, Rienhart and Winston. 1960.

Plattner, J.W. and Herron, L.W. "Simulation: Its Use in Employee Selection". New York. American Management Association. 1962.

Remington Rand Univac. "Marketing Management Simulation". U.2007. New York. Sperry Rand. 1960.

Ricciardi, F.M. et al. "Top Management Decision Simulation". New York. American Management Association. 1957.

Shubik, M. "Bibliography on Simulation, Gaming, Artificial Intelligence and Allied Topics". American Statistical Association Journal, LV. December, 1960.

Thorelli, H.B., and Graves, R.L. "International Operations Simulation". London. Collier McMillan. 1964.

Vance, S. "Management Decision Simulation". New York. McGraw-Hill. 1960.

APPENDIX V

SCALES FOR STATISTICAL ANALYSIS

For the purpose of statistical analysis it is necessary to attach some numerical scale to the answers to the questionnaires. The ideal solution would be to determine objectively, i.e. by means of canonical correlation analysis, the scale which maximises correlations. Such analysis is probably more elaborate than the raw data would justify.

For the analysis in the main body of the paper I selected the scale :

5. Strongly Agree
4. Agree or Tend to Agree
3. Uncertain or Undecided
2. Disagree or Tend to Disagree
1. Strongly Disagree

The ordinal allocation of values is suggested by the presentation above which is as the wording was given to each participant. The cardinality was suggested by the common practice in this area of sociological research.

To examine how sensitive the data was to the selection of scale I re-calculated the correlation and factor analysis with the scale 9, 6, 5, 4, 1. This scale emphasises the extreme views which represents about 18% of total response.

The explained variance from factor analysis was :

	First Scale	New Scale
First Factor	38.436%	36.518%
Second Factor	7.926	7.862%

The factors are therefore the same and the explained variance is effectively the same. It is, however, useful to examine some of the results in detail :

FACTOR 1 JOB RELATION

Variable	First Scale Factor Loading	New Scale Factor Loading	First Scale Rank Order	New Scale Rank Order	Description
36	.774	.734	1	2	My use of information has been affected by participation
1	.749	.762	2	1	The game revealed a number of problem areas for me which I have subsequently pursued
24	.692	.686	3	3	After the time elapsed I can find areas of improvement in my management ability attributable to the game
3	.650	.648	4	6	There has been a change in my approach to management problems
41	.642	.662	5	5	There has been a positive change in my ability to take logical decisions
10	.631	.682	6	4	Experience of the game has taught me to pay more attention to correcting the consequences of faulty decisions in my normal work
59	.607	.592	7	9	The lessons of the game offered me help in solving day-to-day problems

FACTOR 2 LEARNING

Variable	First Scale Factor Loading	New Scale Factor Loading	First Scale Rank Order	New Scale Rank Order	
63	.699	.583	1	4	I would recommend my fellow managers to participate in a similar exercise
13	.677	.731	2	1	I have had some benefit from participating in this business game and feel there is need to repeat the exercise
61	.632	.631	3	3	Games are a practical method of management training
15	.616	.193	4		The game was as useful for the group with which it was used as it would be for training people coming into the industry
57	.604	.384	5	8	A two-day course of lectures on a management subject would not have been of greater value
23	.601	.424	6	5	Playing games is not a waste of time
2	.591	.280	7		I would have gained less participating in a case study
* 48	.564	.713	8	2	A new second game would be valuable to me
* 11	.551	.418	10	6	A game is the best way to use a two-day training meeting in our industry

* Although they had very high factor loadings, these last two items were not included in the original factor as 7 items seemed sufficient. They do, however, reinforce the factor description.

Considering that there are 63 variables the rank orders for both Factors are substantially the same. Those for the Job Relation Factor are very similar. While the same high similarity is not shown in the Learning Factor it is substantially the same and the factor interpretation is unaltered.

It was shown in the thesis that the mean for L was much higher than JR. The figures are:

	First Scale	New Scale
Mean L	3.660	5.979
Mean JR	3.082	5.071

This higher mean was partially because of a heavy weighting of Strongly Agree in several L variables (see below). The exaggeration of this value has caused a small shift in the pattern of similarity between L items but has not changed the factor or its variance explanation.

The means for all factor variables are :

JR Variable	First Scale	New Scale (-2)	Major Differences
36	3.201	3.232	
1	2.969	2.897	
24	3.216	3.237	
3	3.067	3.036	
41	2.763	2.711	
10	3.139	3.129	
59	3.222	3.253	
L Variable	**First Scale**	**New Scale**	**Major Differences**
63	4.062	4.794	+.732
13	3.175	3.237	
61	4.005	4.490	+.485
15	3.948	4.320	+.360
57	3.443	3.546	
23	4.294	5.139	+.845
2	3.175	3.175	
48	3.443	3.619	
11	3.397	3.490	

The only major differences are in 4 of the L variables. These have all risen substantially. This means that the First Scale was "hiding" a substantial number of Strongly Agrees by matching them with Disagrees and Undecideds. An analysis of these 4 statements shows that they all deal with the practicality of business games :

23 Playing games is not a waste of time

63 I would recommend my fellow managers to participate in a similar exercise

61 Games are a practical method of management training

15 The game was as useful for the group with which it was used as it would be for training people coming into the industry

It might therefore be said that while the average opinion on the games practicality was very high it had been weighted by high individuals. Four of the other five L items deal with the games comparability - that is, as against other techniques.

The correlations for 'all data' discussed in the text are listed below :

Correlation	First Scale	Second Scale
10/1	+0.523	+0.528
10/24	+0.537	+0.479
10/30	+0.510	+0.506
10/36	+0.511	+0.486
19/52	+0.668	+0.635
24/36	+0.591	+0.543
30/57	+0.590	+0.508
30/3	+0.521	+0.483

Although they are all almost the same, only one, 10/1, is higher. This is prbably because the new scale causes, in effect, a delusion of the central data which is most often highly correlated.

C O N C L U S I O N S

Ideally a canonical analysis of the data should have been done to determine the scale used in analysis. The data probably would not stand up to this. Therefore, the best procedure was to carry out some kind of sensitivity analysis on the scale employed.

Clearly, wild variations in scale would not have been sensible. Hence the most appropriate exercise to undertake in order to test the sensitivity of the results to the scale employed was simply to run through the analysis again with a significant but not substantial variation of the weightings attached to the ordinal scale. The scale decided on was :

9 Strongly Agree
6 Agree or Tend to Agree
5 Uncertain or Undecided
4 Disagree or Tend to Disagree
1 Strongly Disagree

Of course, obtaining substantially similar results does not constitute a proof that the analysis is insensitive to scale. However, essentially similar conclusions emerging from two scales covering the range of feasible sensible magnitudes does add considerably to my confidence in the results.

The variance explained by the factors is effectively unchanged and because of the size of the value of JR explained variance, it will probably remain a factor through very substantial shifts in scale. The factor interpretations are also unchanged by this scale change.

The fact that the data has shown itself essentially insensitive to this change of scale is most important. It gives further confidence in the conclusions which were drawn from the use of the first scale. That is - while not being a proof of the insensitivity of the data to significant scale changes it does give greater confidence in the results.

I therefore feel that I can restate the most important conclusions drawn in the thesis :

> If the participants felt that the game was practical and enjoyable, their attitudes show that they feel that they learned something which is related to their job.
>
> The two games which were used in this analysis are important tools for learning in several areas of management studies. These areas are : decision taking, use of information and problem solving.